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Eger et al.

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(45) **Date of Patent: Jun. 27, 2023**

(54) **PEAK SUPPRESSION INFORMATION MULTIPLEXING ON DOWNLINK SHARED CHANNEL**

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H04L 5/02	(2006.01)
H04L 27/26	(2006.01)

(52) **U.S. Cl.**

CPC ***H04L 5/023*** (2013.01); ***H04L 5/0007*** (2013.01); ***H04L 5/0053*** (2013.01); ***H04L 27/2624*** (2013.01); *H04L 27/2628* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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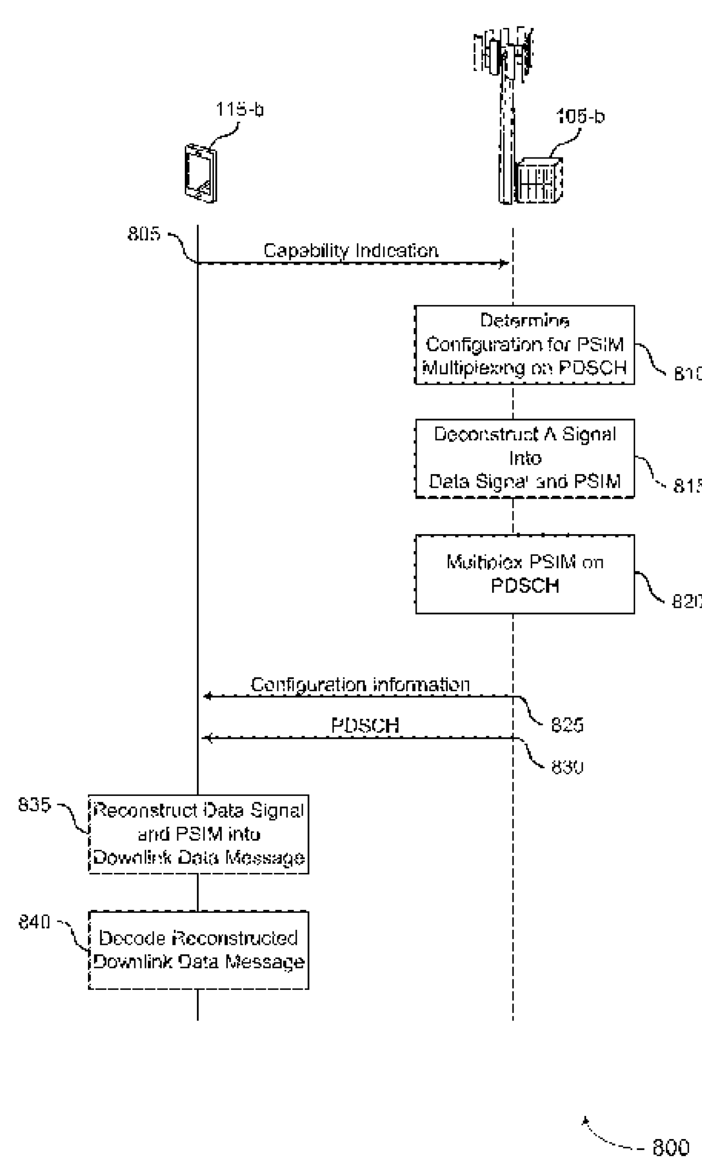
(57) **ABSTRACT**

A base station may multiplex a peak suppression information message (PSIM) on a physical downlink shared channel (PDSCH) with data for efficient implementation of PSIMs for peak to average power ratio (PAPR) reduction. A base station may clip peaks from a signal to be transmitted and capture information of the clipped peaks into a PSIM. The base station may then multiplex the PSIM on the PDSCH such that a receiving device (for example, a user equipment (UE)) may receive the signal and reconstruct the signal (for example, PDSCH data) using the PSIM. According to some aspects, each PDSCH symbol may include a PSIM for a previous PDSCH symbol, or the PSIM may be for the current symbol. Various aspects of the techniques described herein may further provide for PSIM positioning in frequency, PSIM modulation, PSIM channel coding, PSIM multiple-input multiple-output (MIMO) configurations, among other examples.

28 Claims, 20 Drawing Sheets



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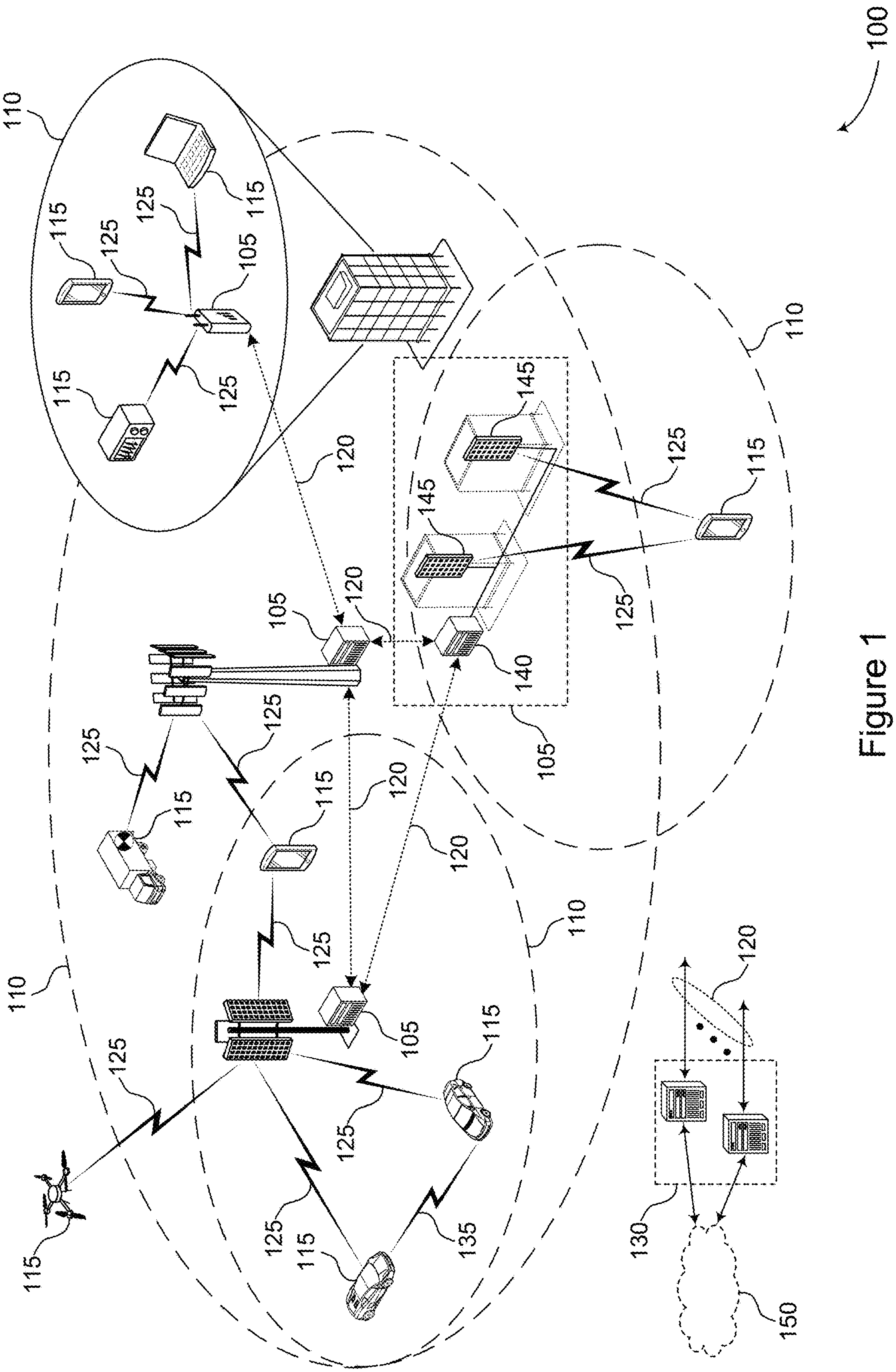


Figure 1

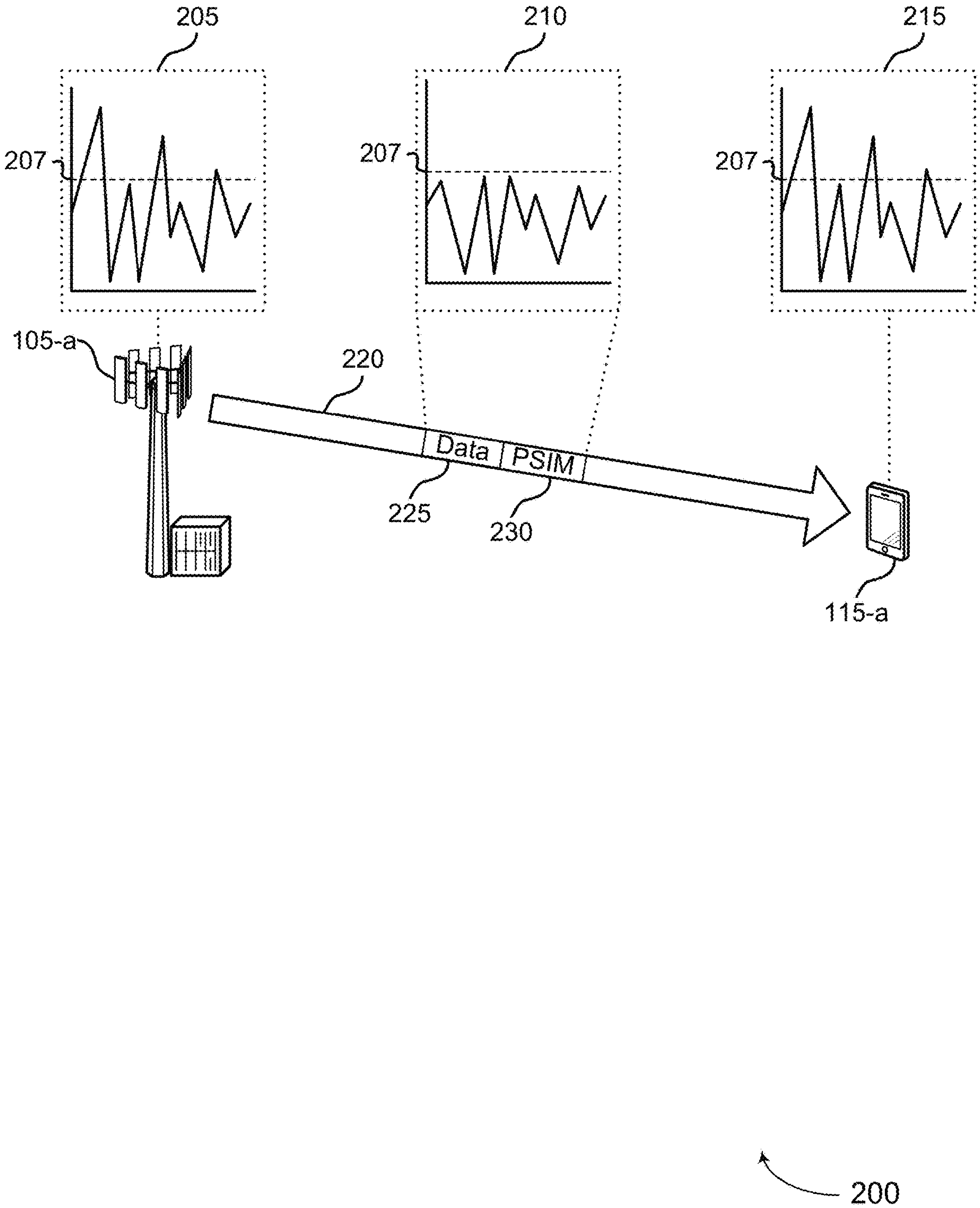
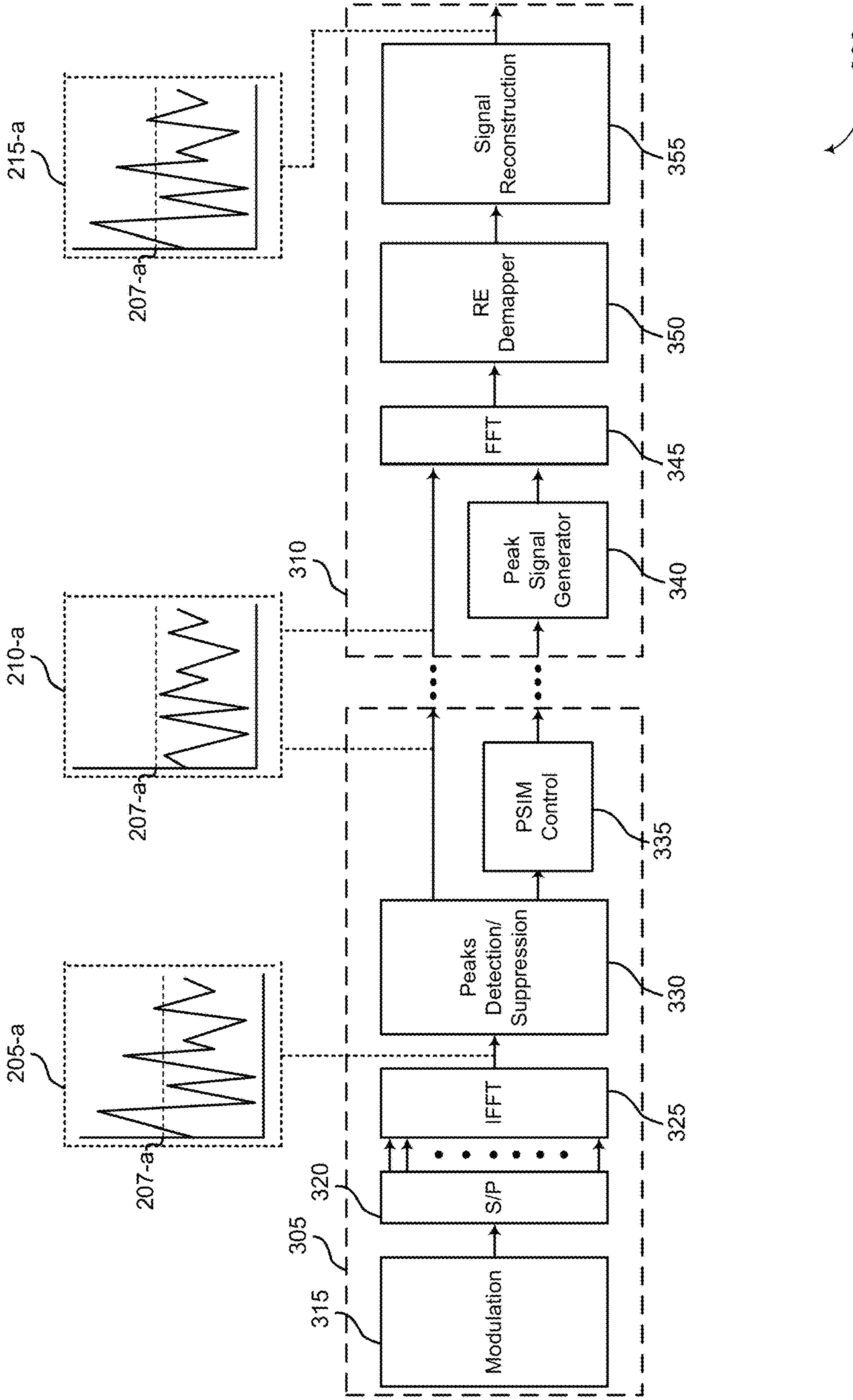


Figure 2



205-a
207-a
210-a
207-a
215-a
207-a
Modulation
315
305
S/P
320
IFFT
325
Peaks Detection/ Suppression
330
PSIM Control
335
Peak Signal Generator
340
FFT
345
RE Demapper
350
Signal Reconstruction
355
310
300

Figure 3

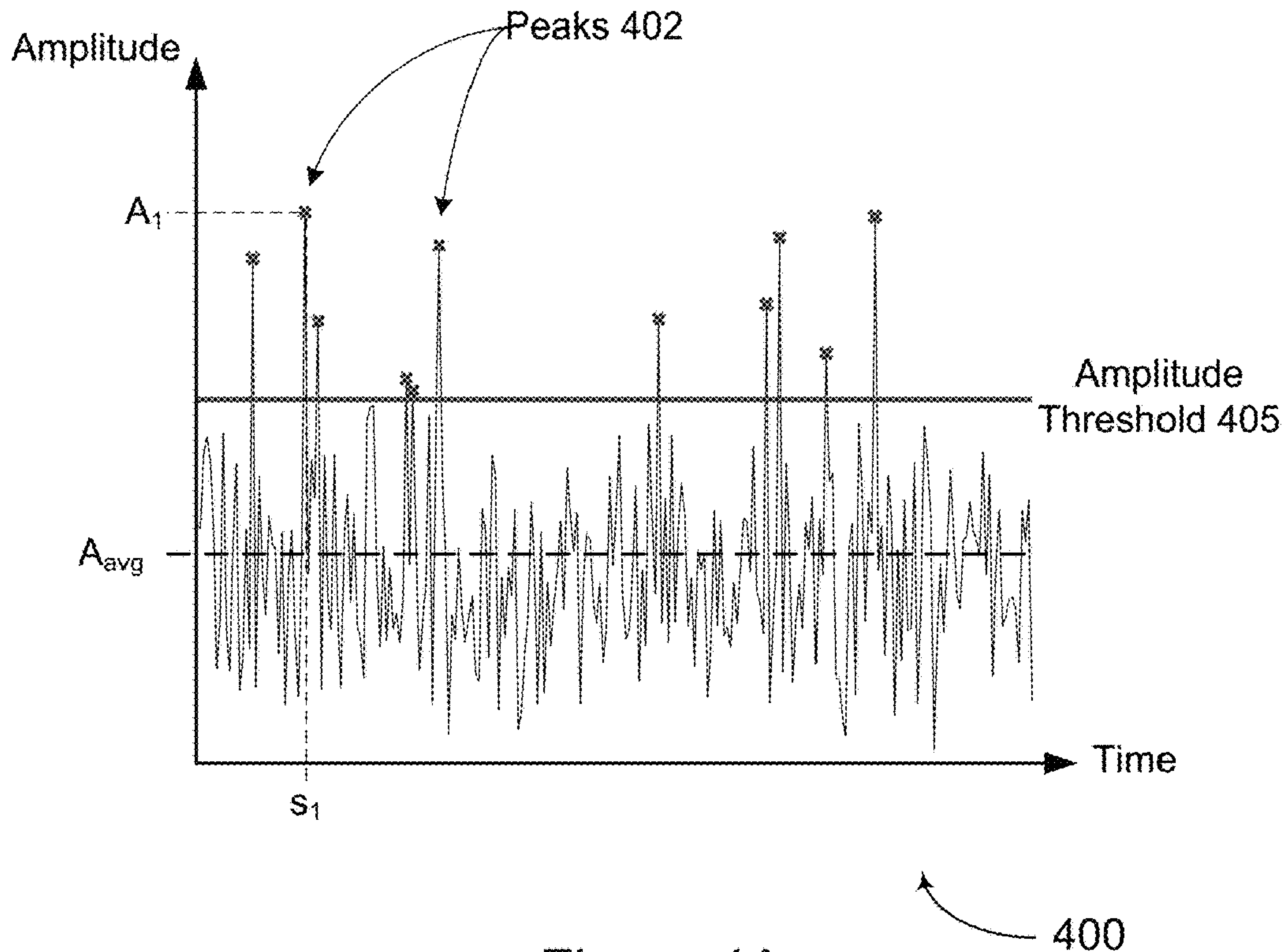


Figure 4A

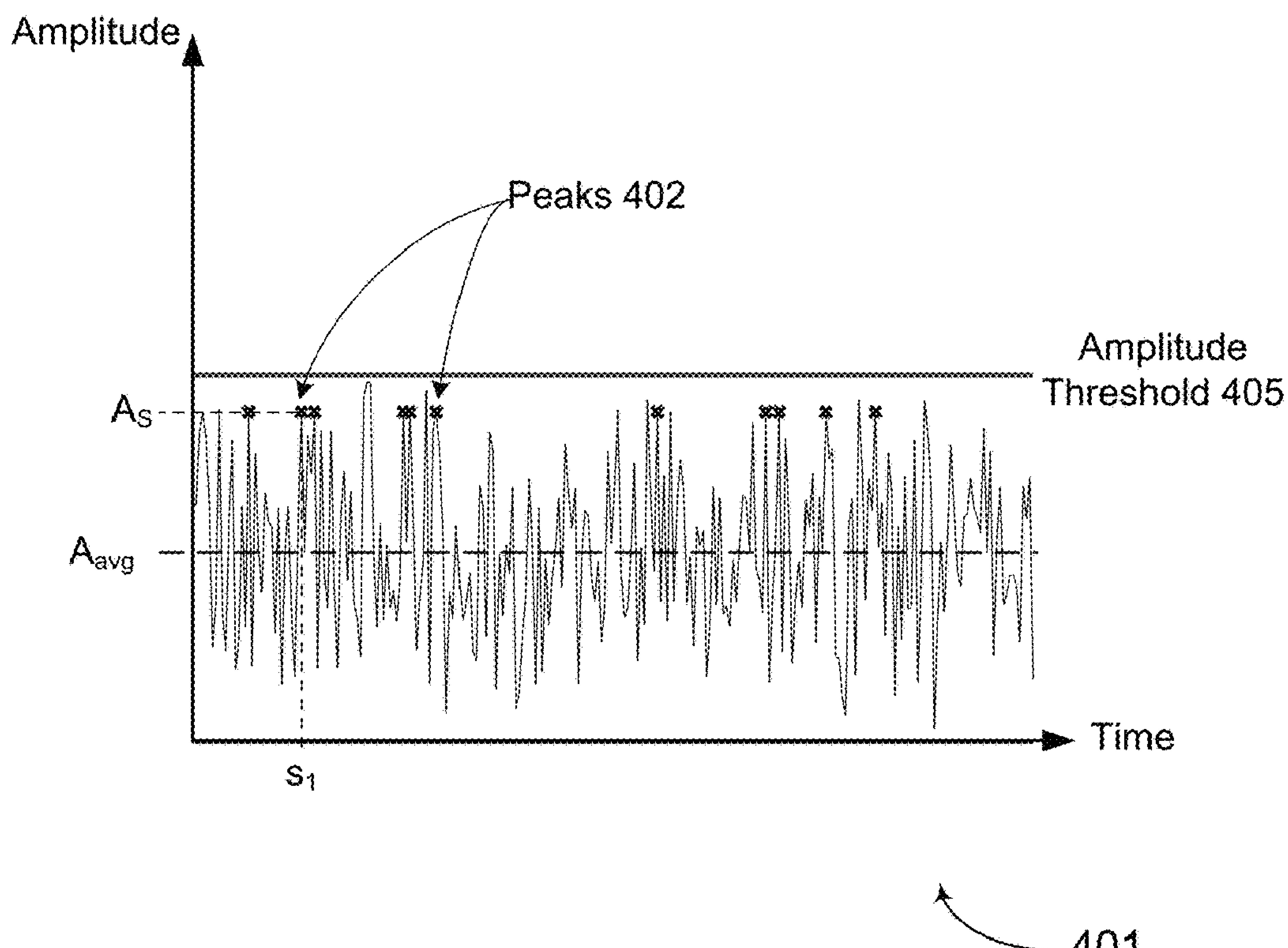


Figure 4B

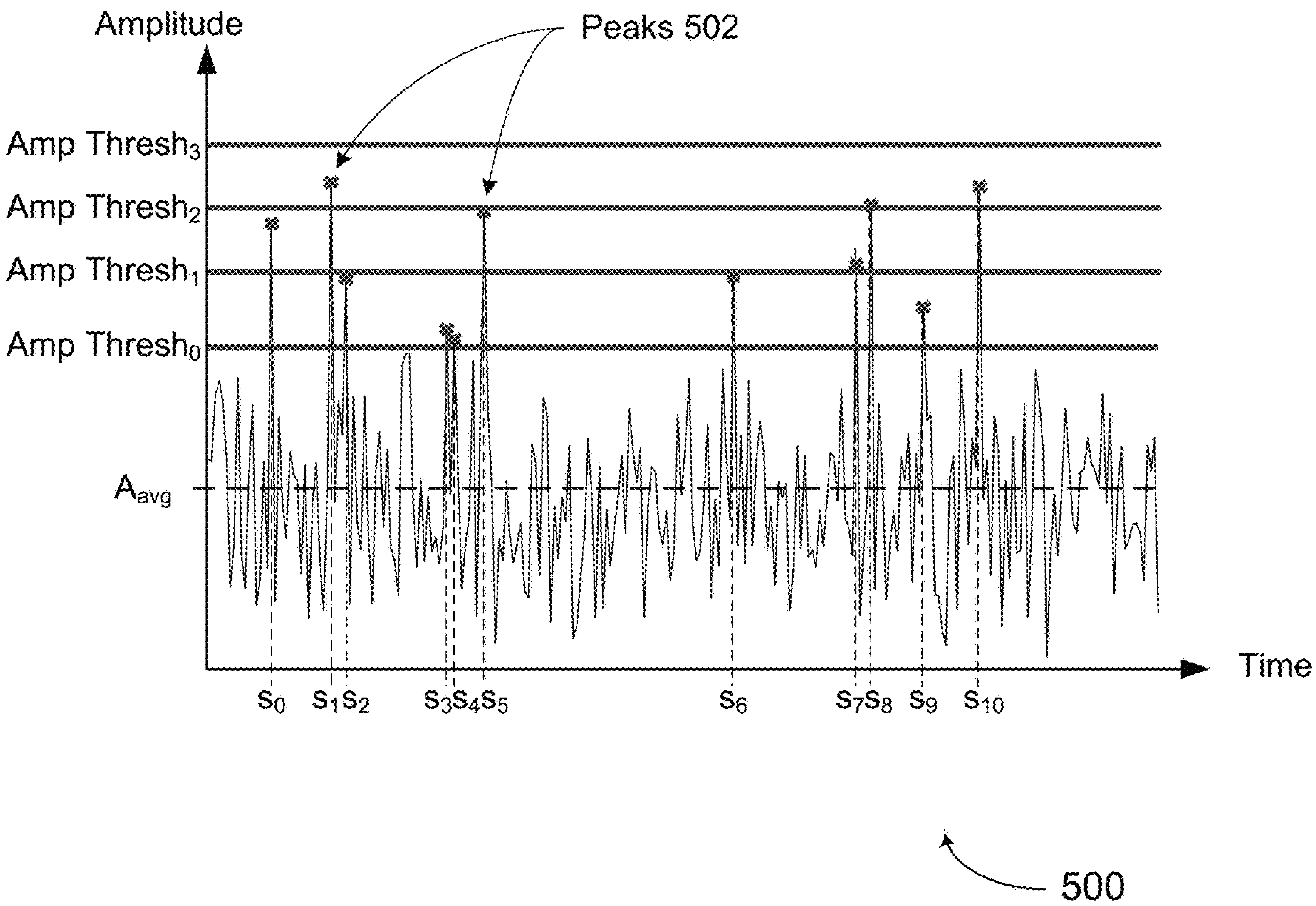

Amplitude
Peaks 502
Amp Thresh3
Amp Thresh2
Amp Thresh1
Amp Thresh0
Aavg
Time
S0
S1
S2
S3
S4
S5
S6
S7
S8
S9
S10
500

Figure 5

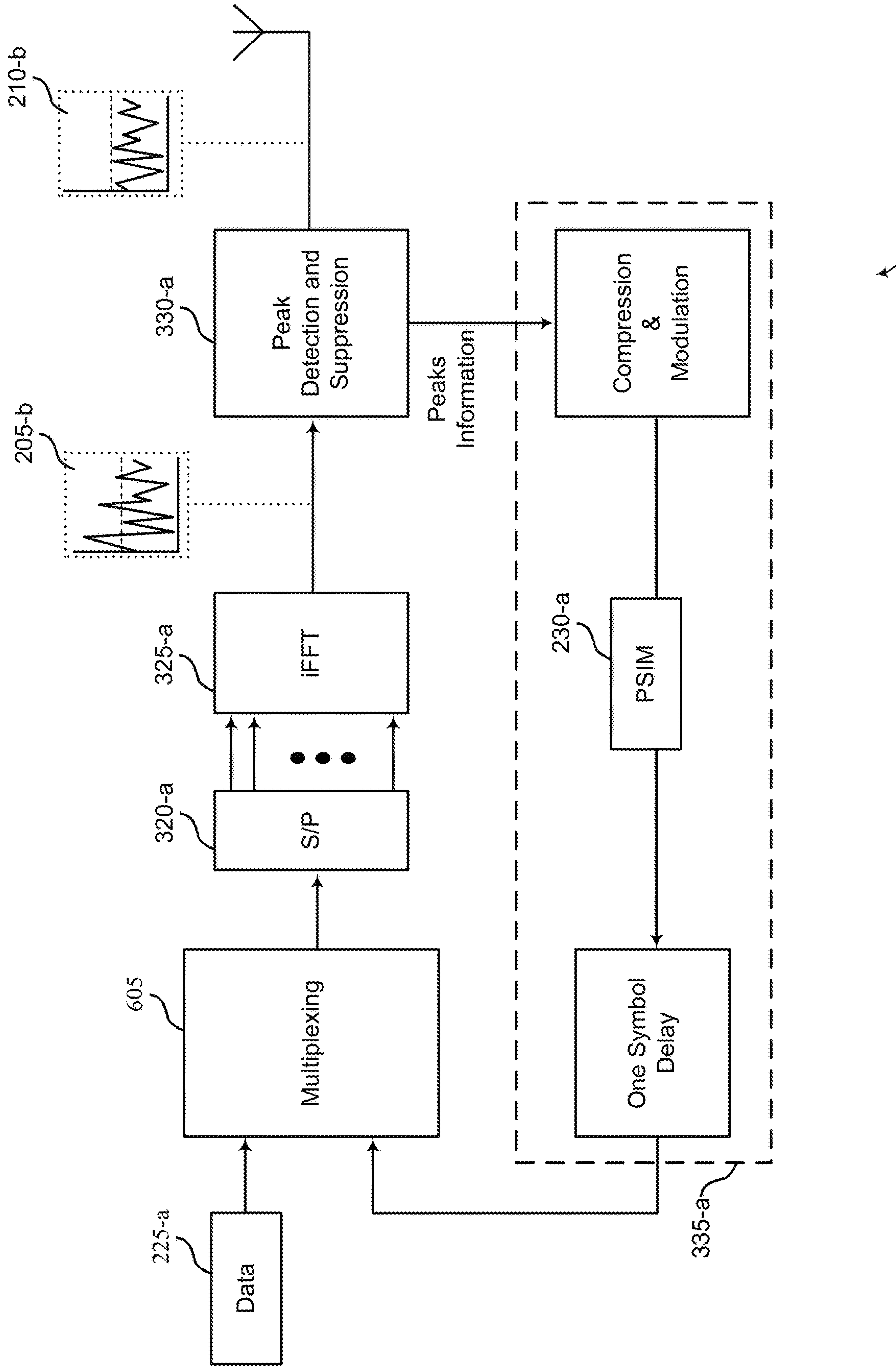
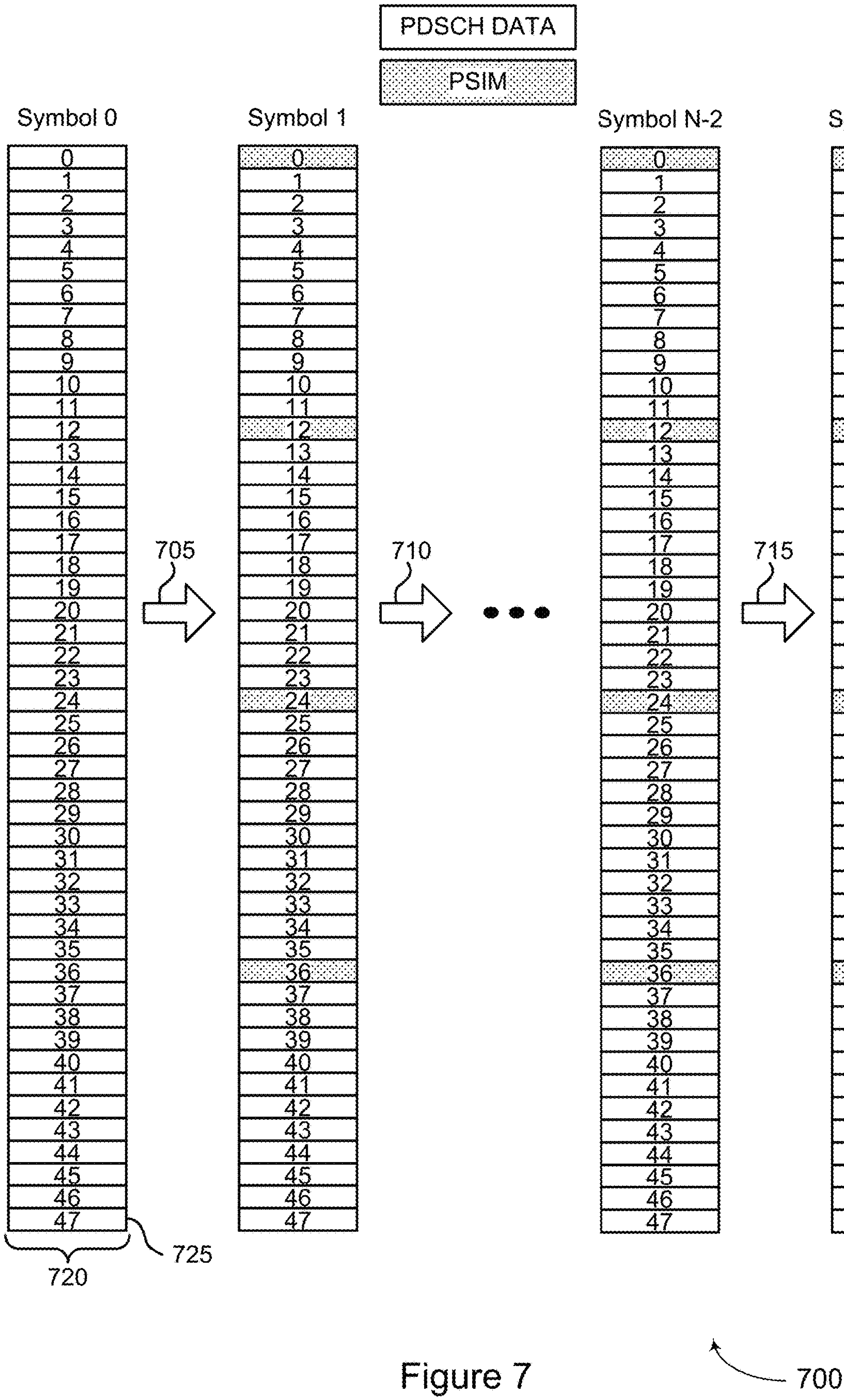

210-b
205-b
330-a
Peak Detection and Suppression
Peaks Information
Compression & Modulation
600
325-a
iFFT
230-a
PSIM
320-a
S/P
605
Multiplexing
One Symbol Delay
225-a
Data
335-a

Figure 6


PDSCH DATA
PSIM
Symbol 0
Symbol 1
Symbol N-2
Symbol N-1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
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40
41
42
43
44
45
46
47
705
710
715
720
725
700

Figure 7

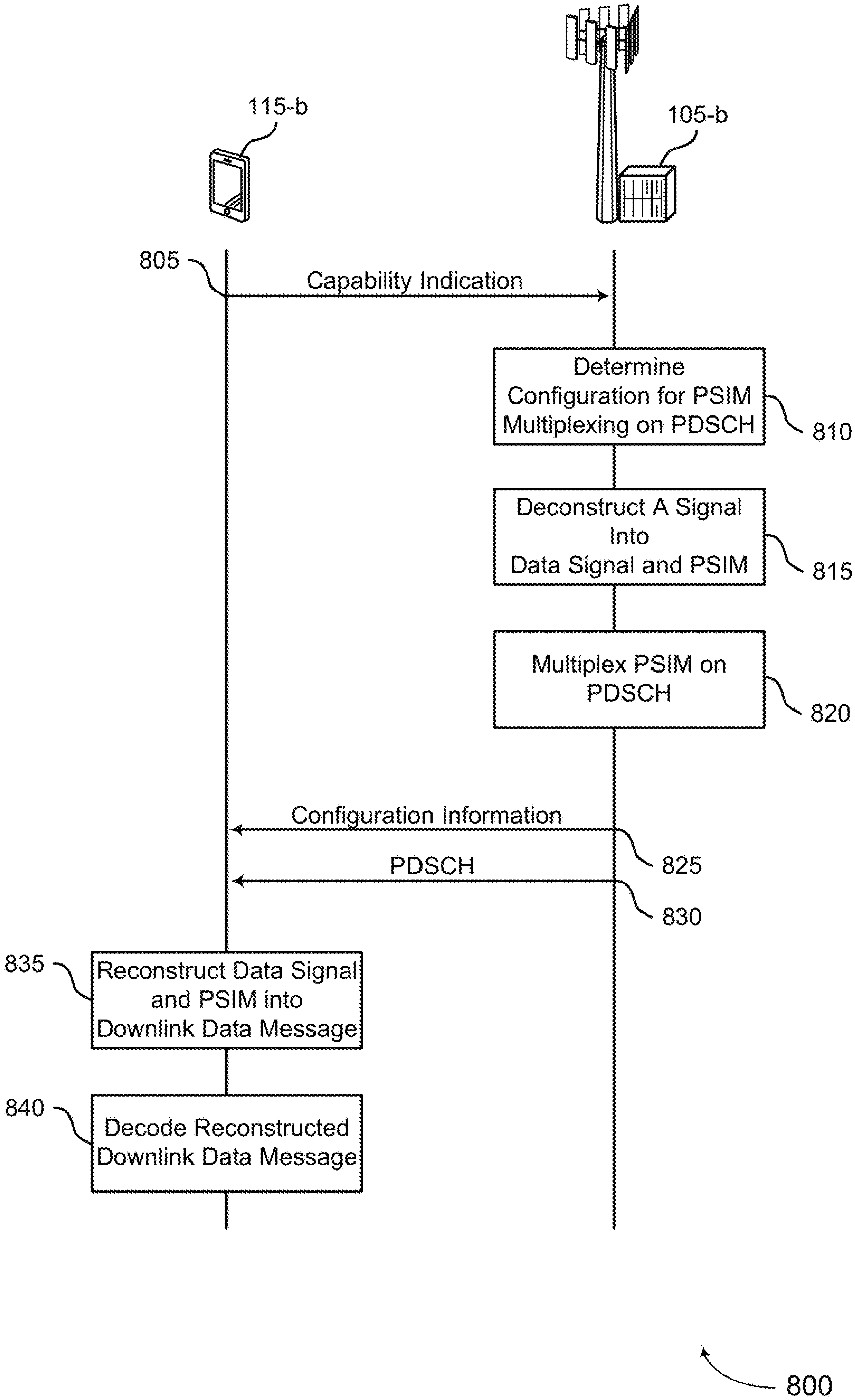

115-b
105-b
805
Capability Indication
Determine Configuration for PSIM Multiplexing on PDSCH
810
Deconstruct A Signal Into Data Signal and PSIM
815
Multiplex PSIM on PDSCH
820
Configuration Information
825
PDSCH
830
835
Reconstruct Data Signal and PSIM into Downlink Data Message
840
Decode Reconstructed Downlink Data Message
800

Figure 8

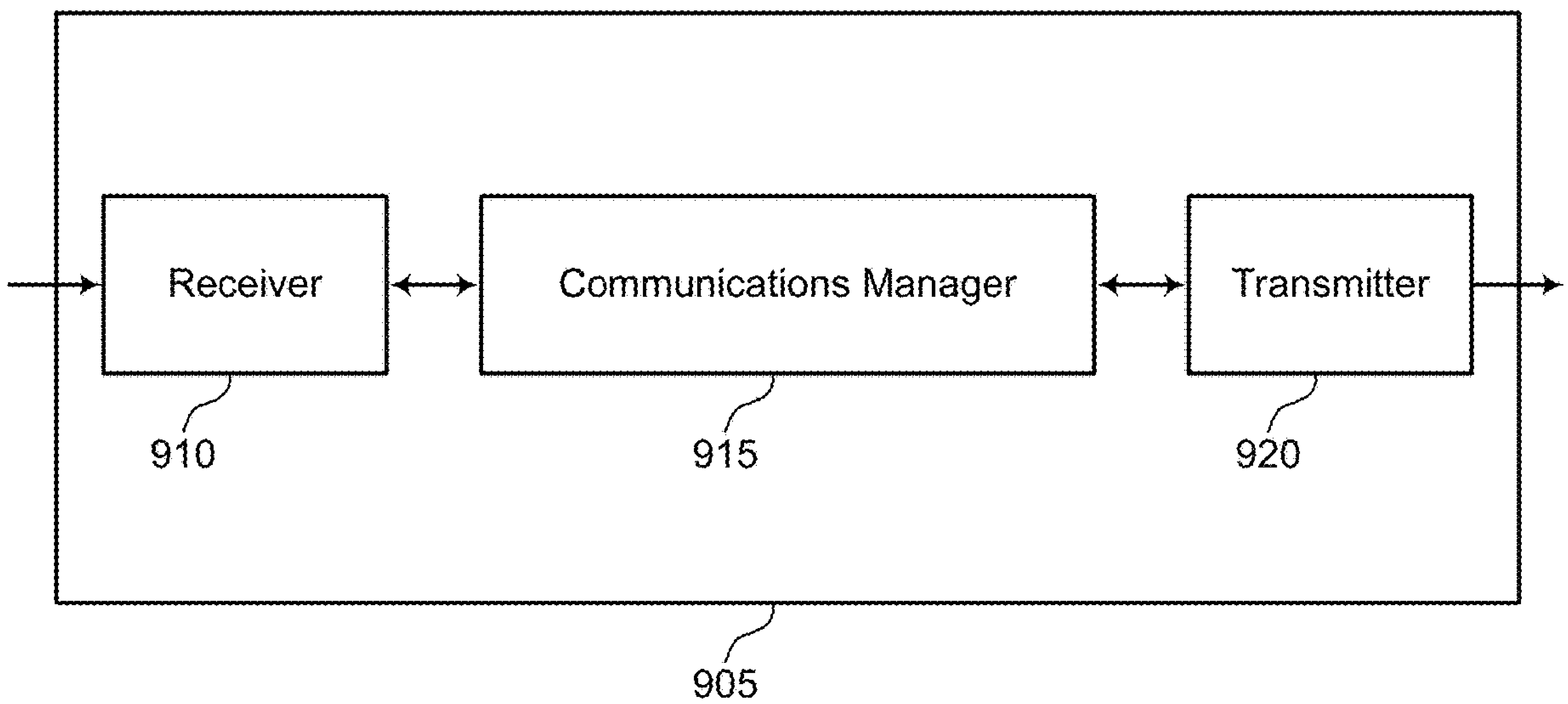
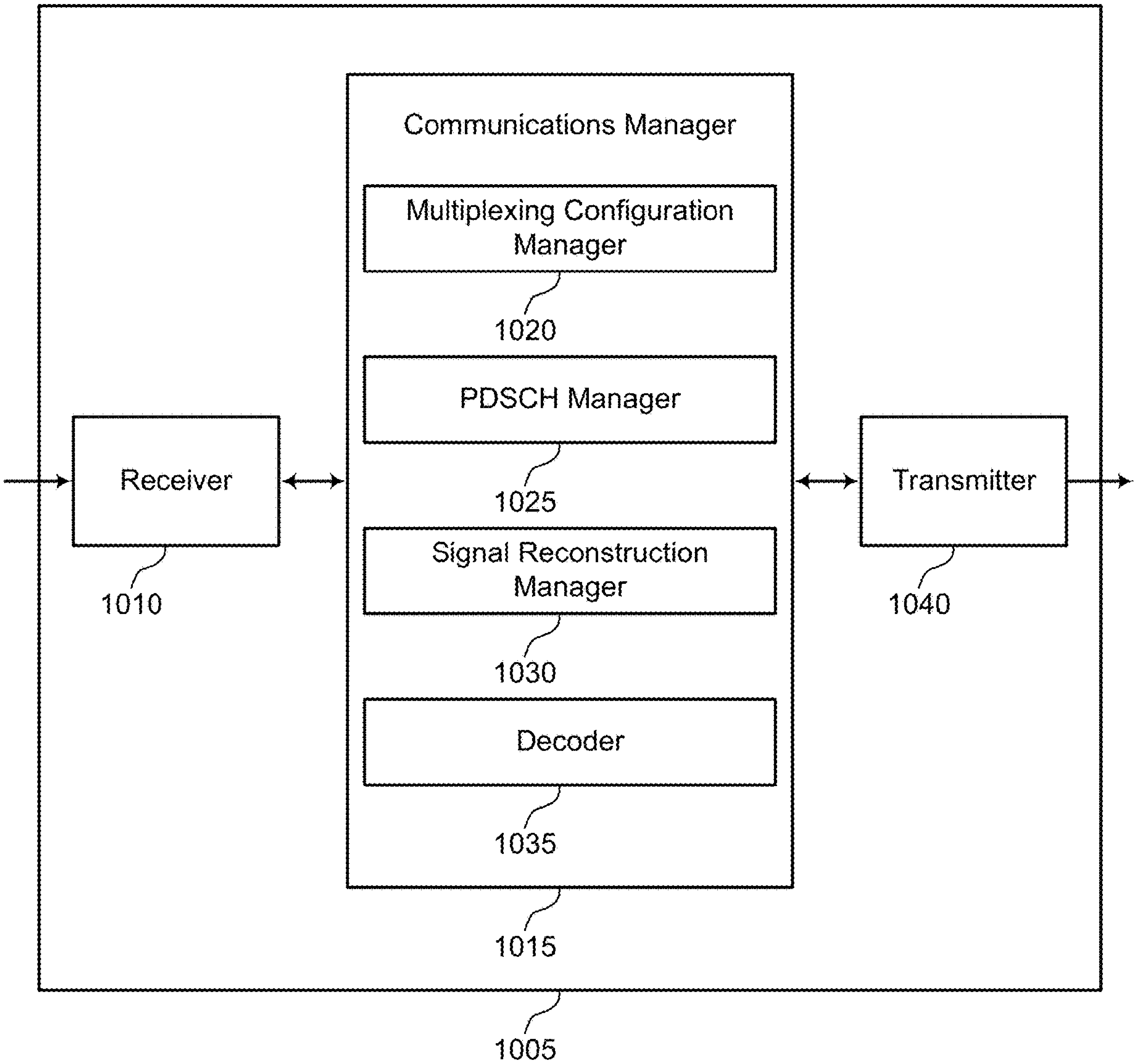

Receiver
Communications Manager
Transmitter
910
915
920
905

Figure 9



Communications Manager
Multiplexing Configuration Manager
1020
PDSCH Manager
1025
Signal Reconstruction Manager
1030
Decoder
1035
1015
Receiver
1010
Transmitter
1040
1005

Figure 10

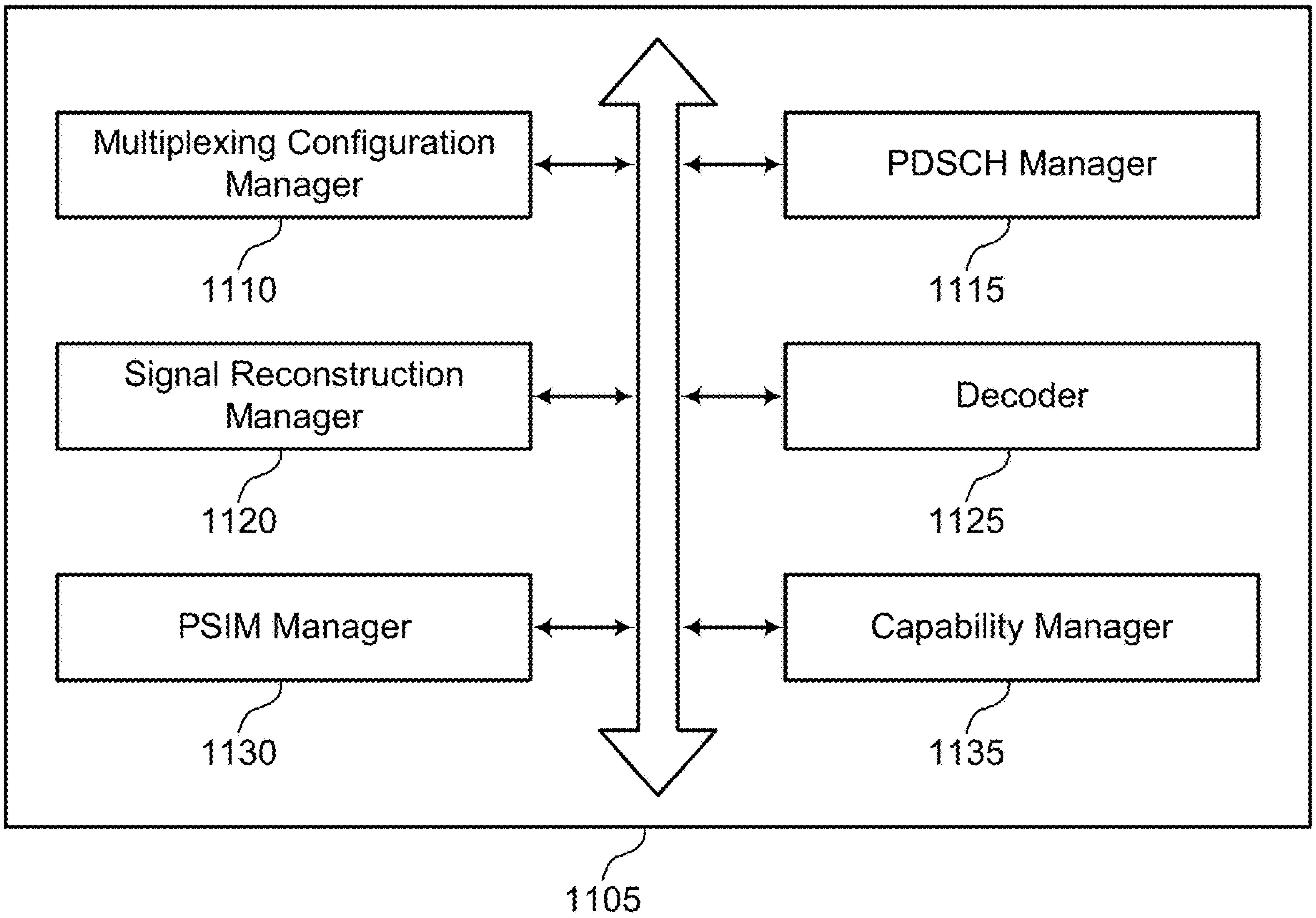

Multiplexing Configuration Manager
1110
PDSCH Manager
1115
Signal Reconstruction Manager
1120
Decoder
1125
PSIM Manager
1130
Capability Manager
1135
1105

Figure 11

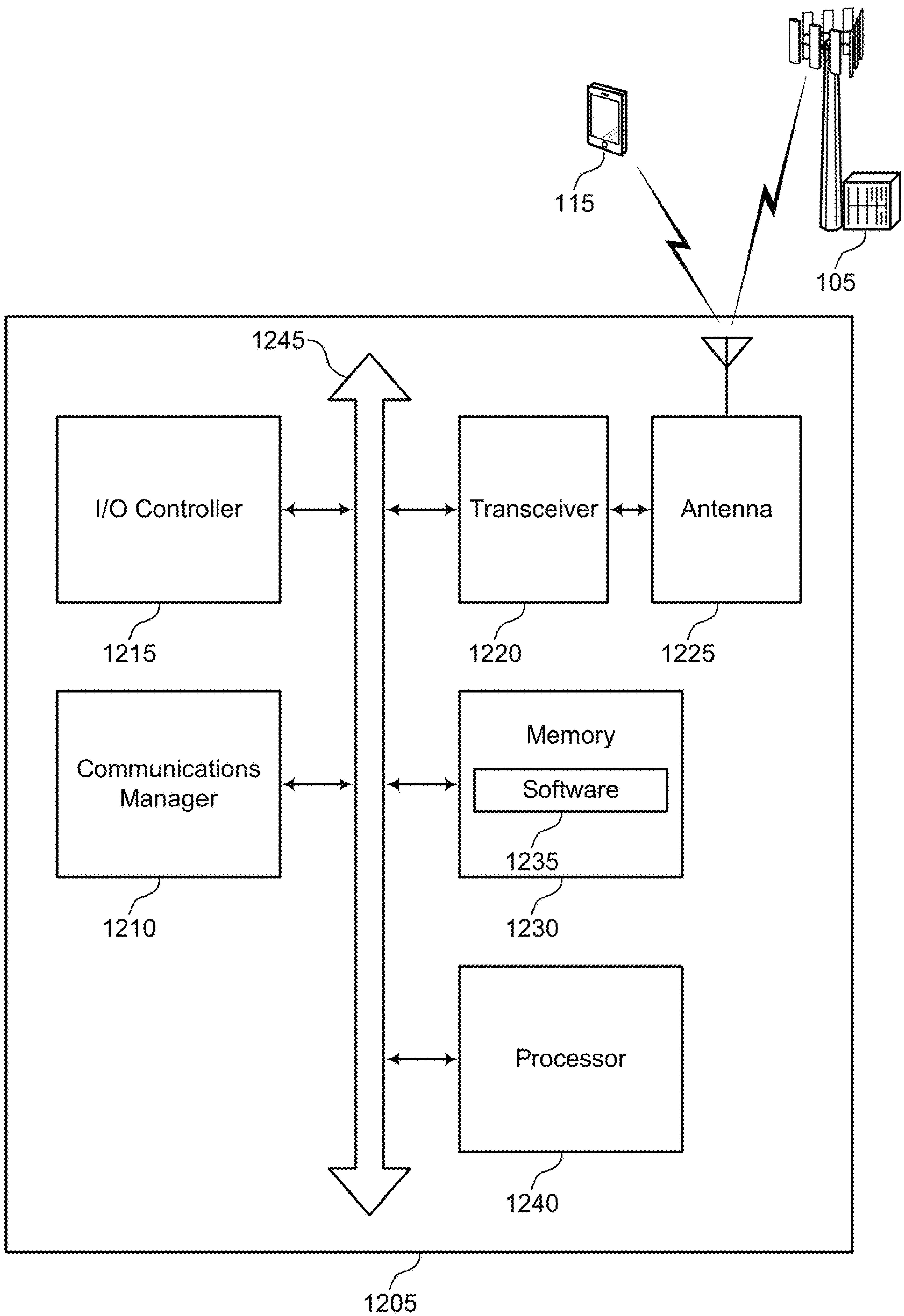

115
105
1245
I/O Controller
Transceiver
Antenna
1215
1220
1225
Communications Manager
Memory
Software
1235
1210
1230
Processor
1240
1205

Figure 12

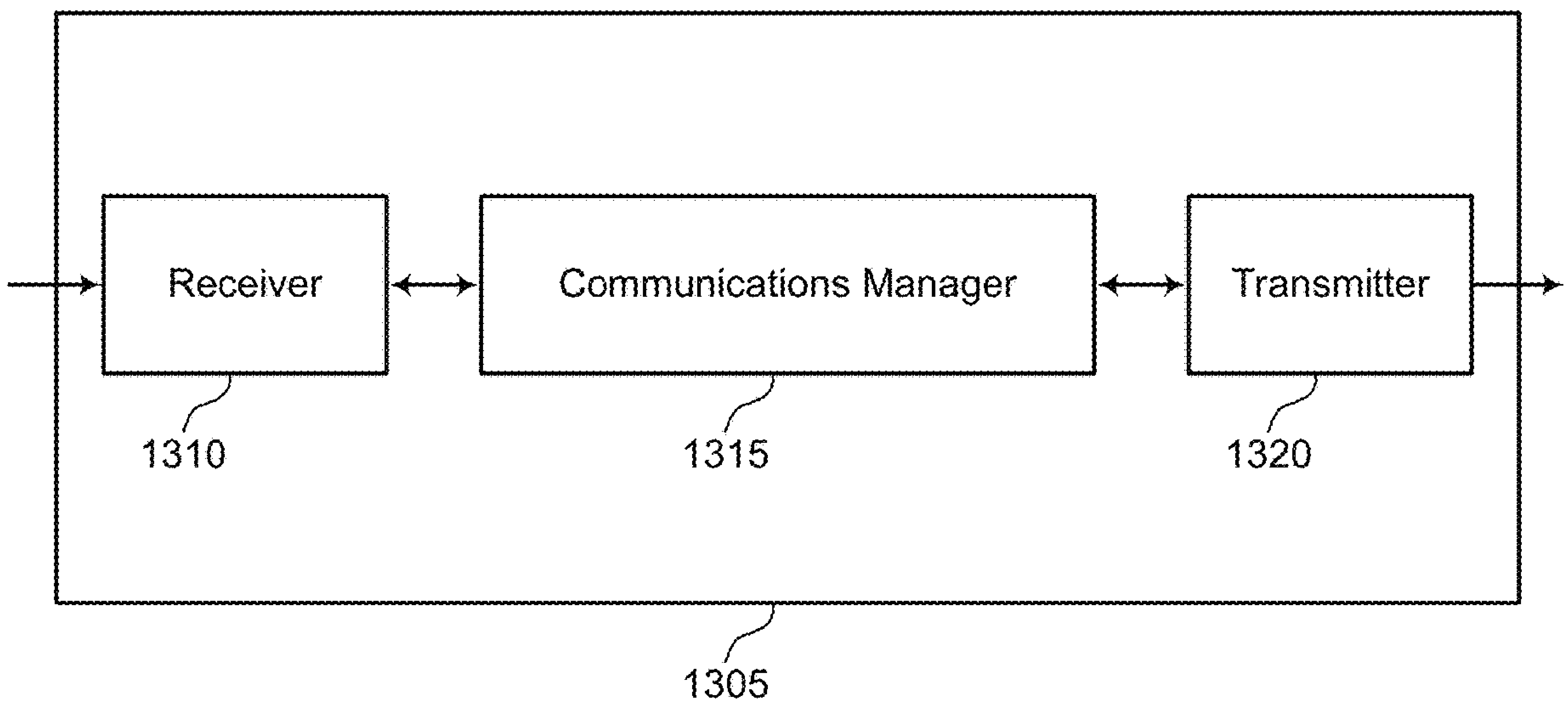

Receiver
Communications Manager
Transmitter
1310
1315
1320
1305

Figure 13

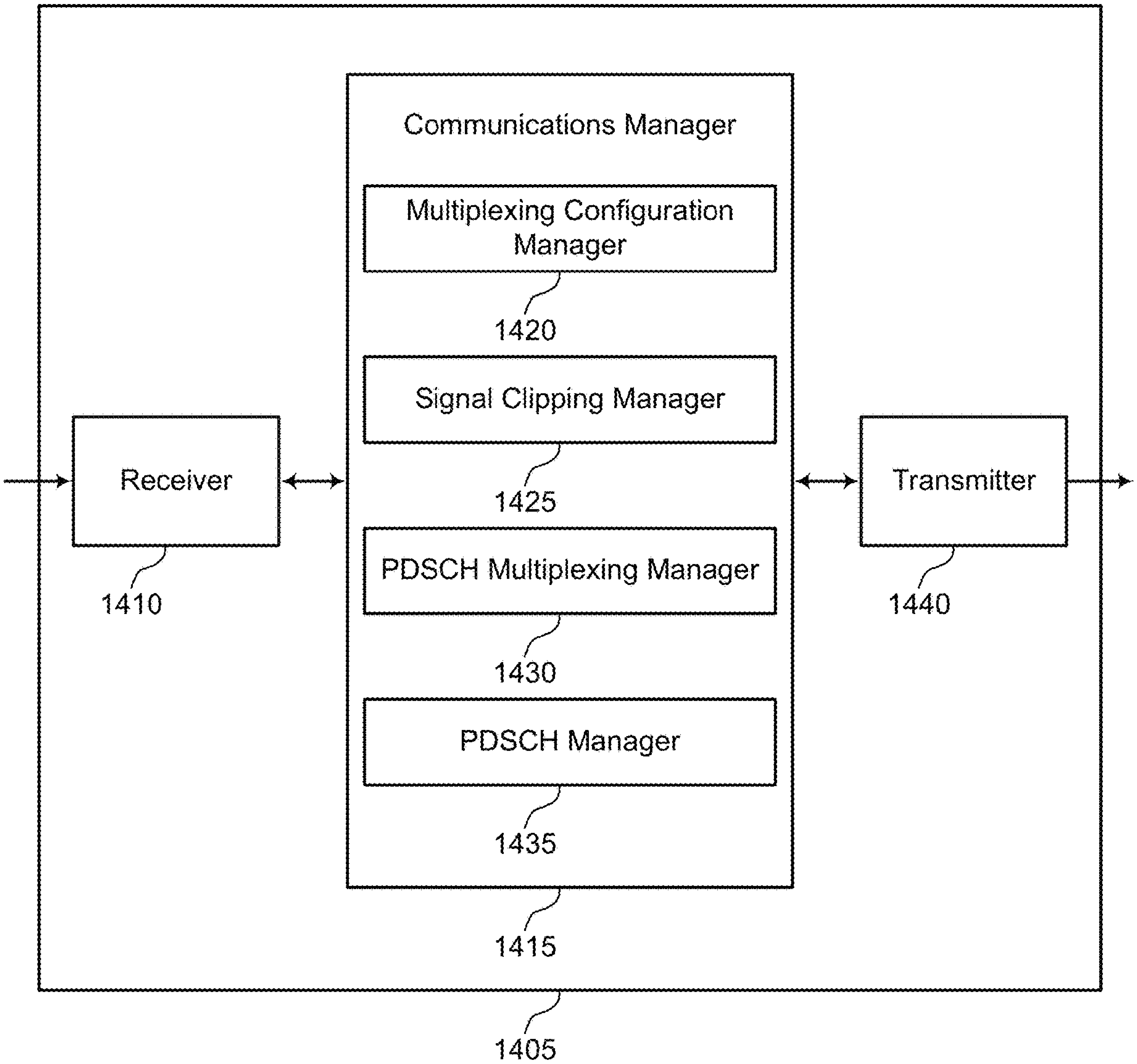

Communications Manager
Multiplexing Configuration Manager
1420
Signal Clipping Manager
1425
Receiver
Transmitter
1410
PDSCH Multiplexing Manager
1440
1430
PDSCH Manager
1435
1415
1405

Figure 14

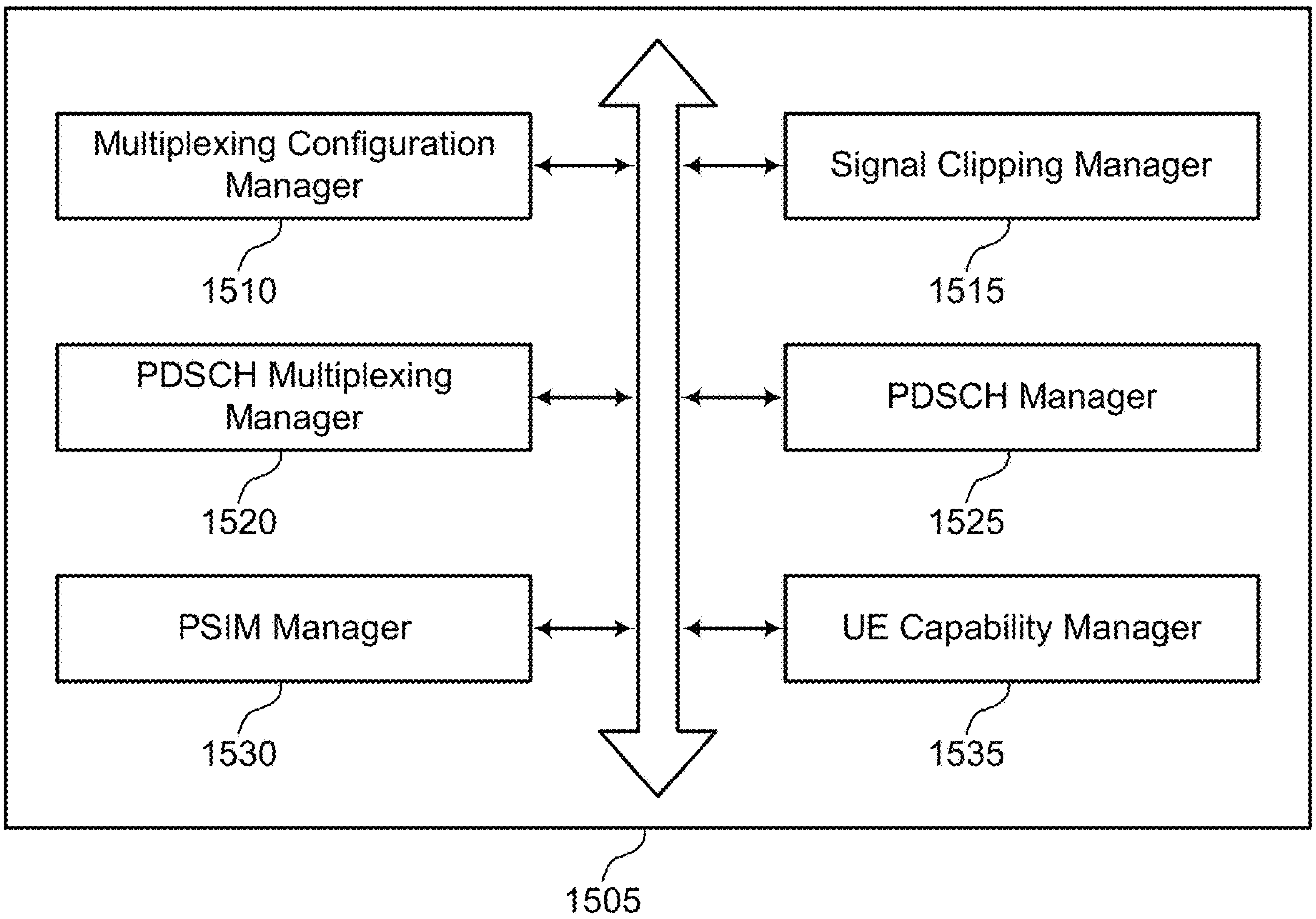
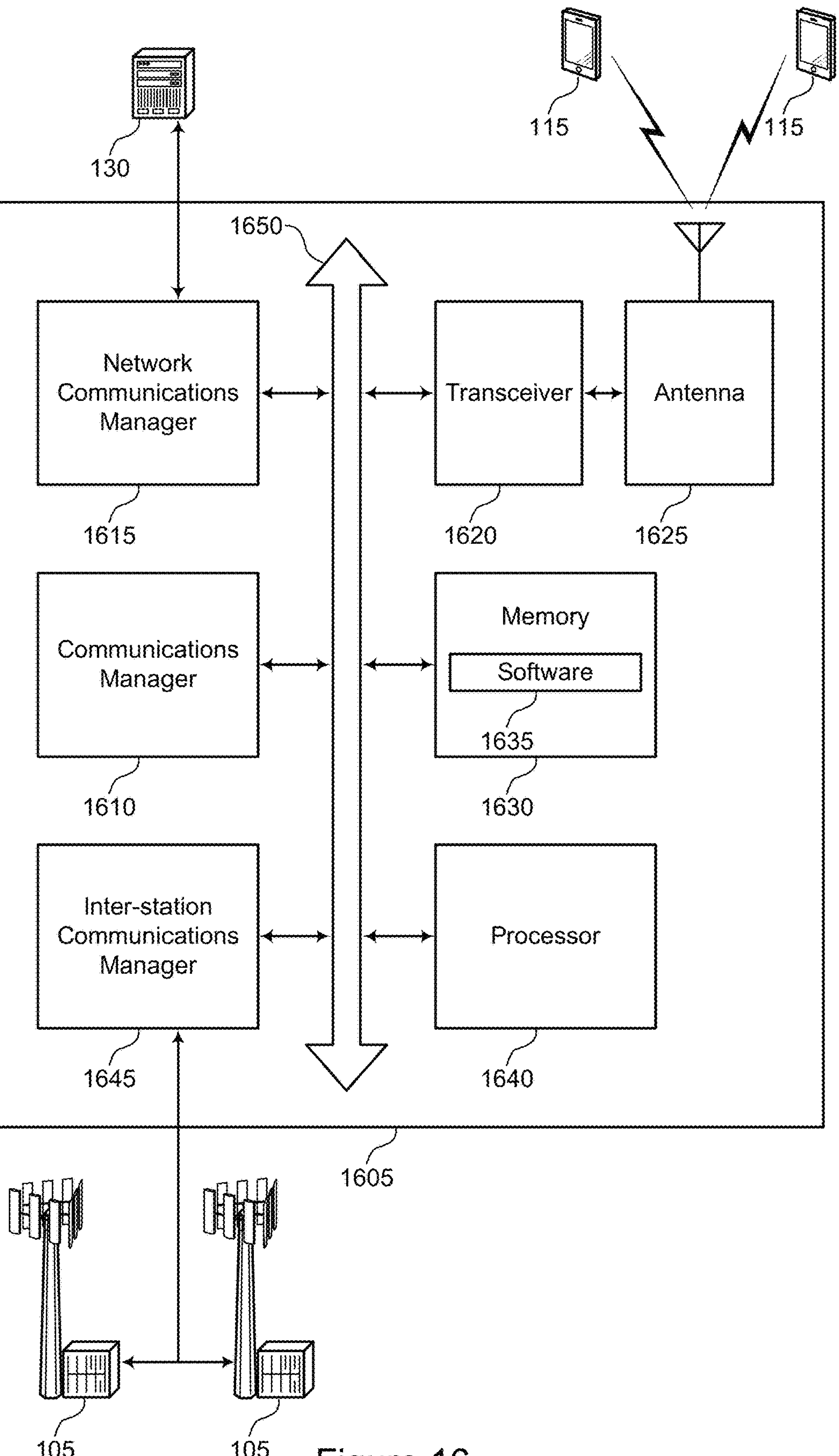

Multiplexing Configuration Manager
1510
PDSCH Multiplexing Manager
1520
PSIM Manager
1530
Signal Clipping Manager
1515
PDSCH Manager
1525
UE Capability Manager
1535
1505

Figure 15



130
115
115
1650
Network Communications Manager
Transceiver
Antenna
1615
1620
1625
Communications Manager
Memory
Software
1635
1610
1630
Inter-station Communications Manager
Processor
1645
1640
1605
105
105

Figure 16

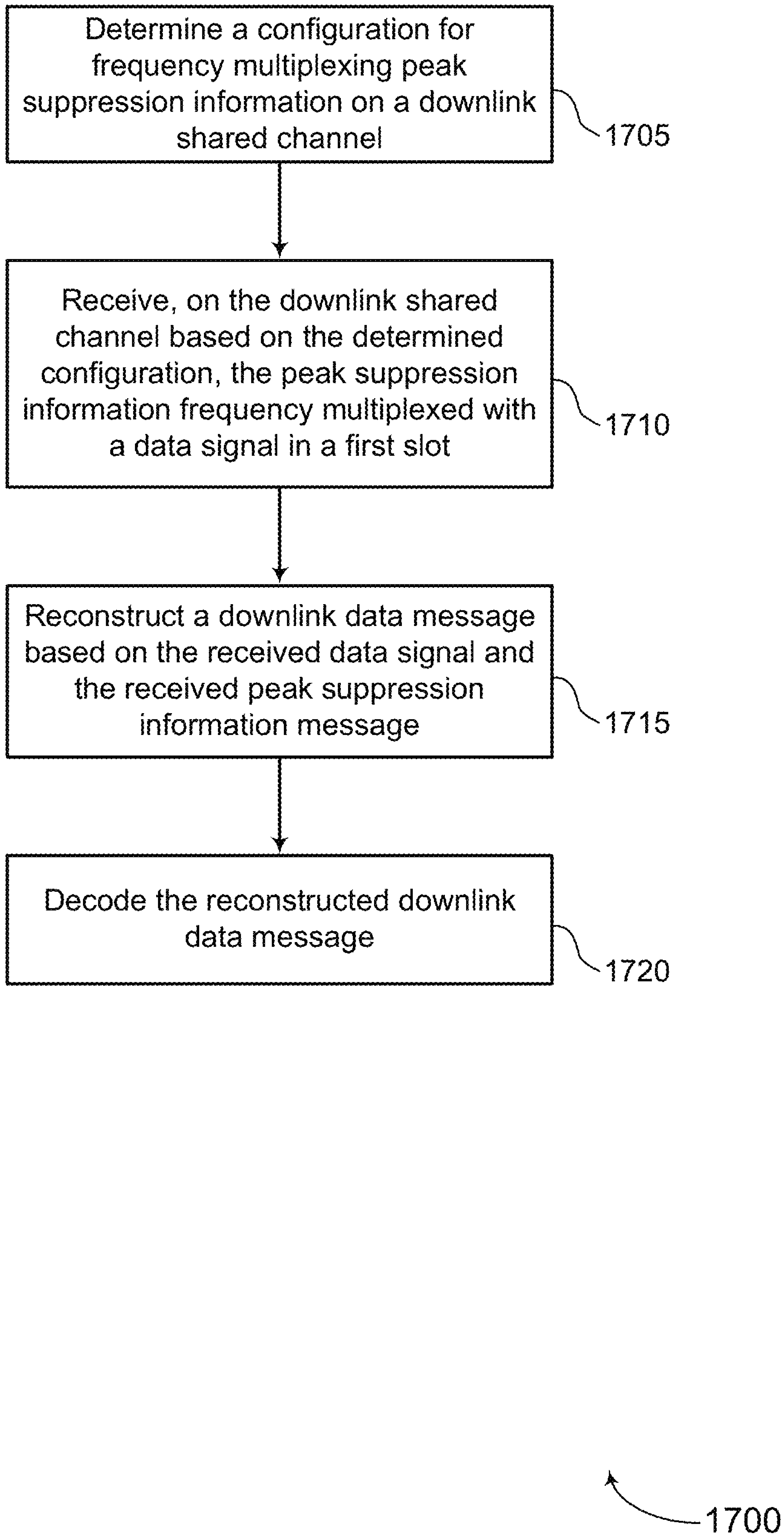

Determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel
1705
Receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot
1710
Reconstruct a downlink data message based on the received data signal and the received peak suppression information message
1715
Decode the reconstructed downlink data message
1720
1700

Figure 17

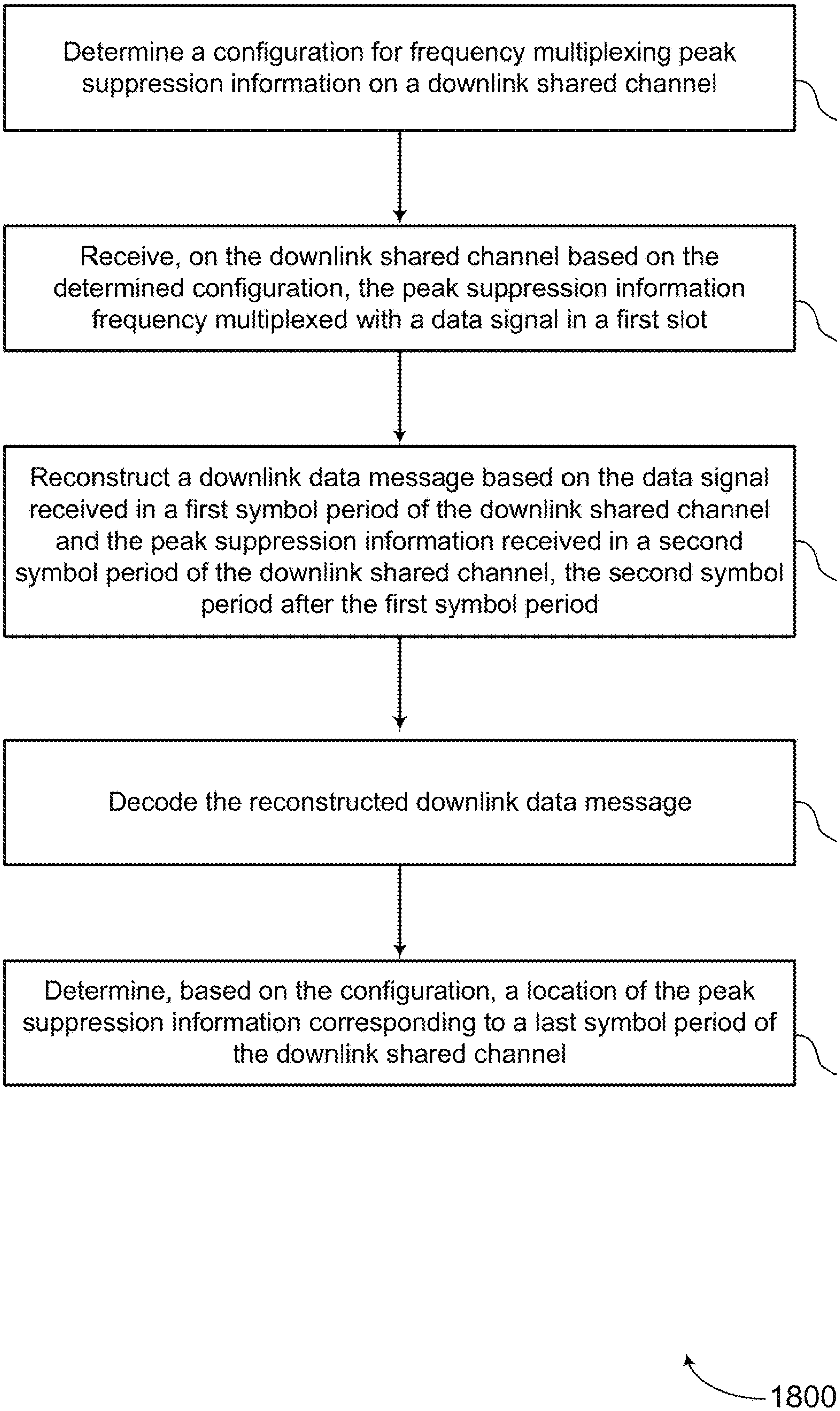

Determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel
1805
Receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot
1810
Reconstruct a downlink data message based on the data signal received in a first symbol period of the downlink shared channel and the peak suppression information received in a second symbol period of the downlink shared channel, the second symbol period after the first symbol period
1815
Decode the reconstructed downlink data message
1820
Determine, based on the configuration, a location of the peak suppression information corresponding to a last symbol period of the downlink shared channel
1825
1800

Figure 18

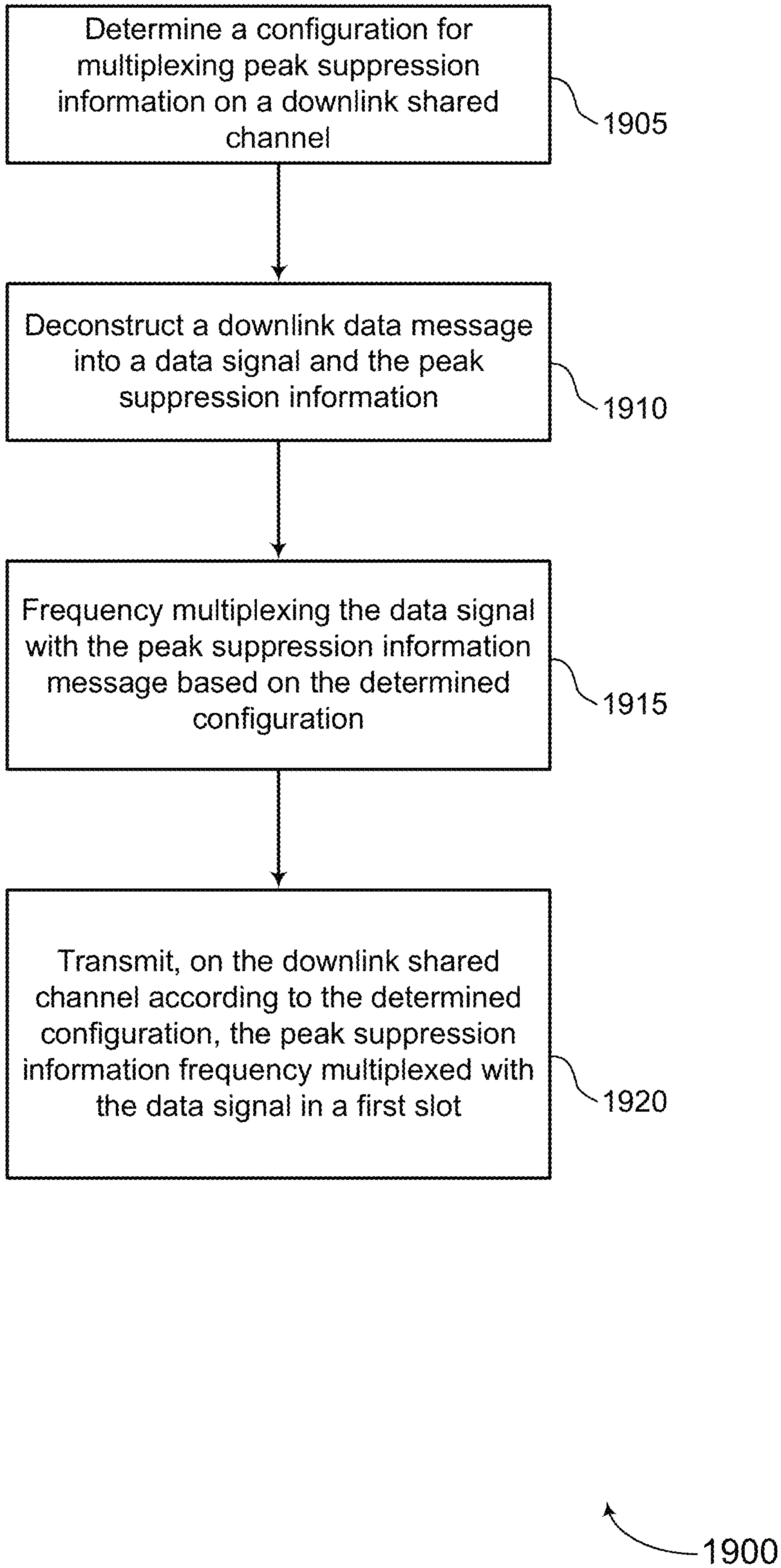

Determine a configuration for multiplexing peak suppression information on a downlink shared channel
1905
Deconstruct a downlink data message into a data signal and the peak suppression information
1910
Frequency multiplexing the data signal with the peak suppression information message based on the determined configuration
1915
Transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot
1920
1900

Figure 19

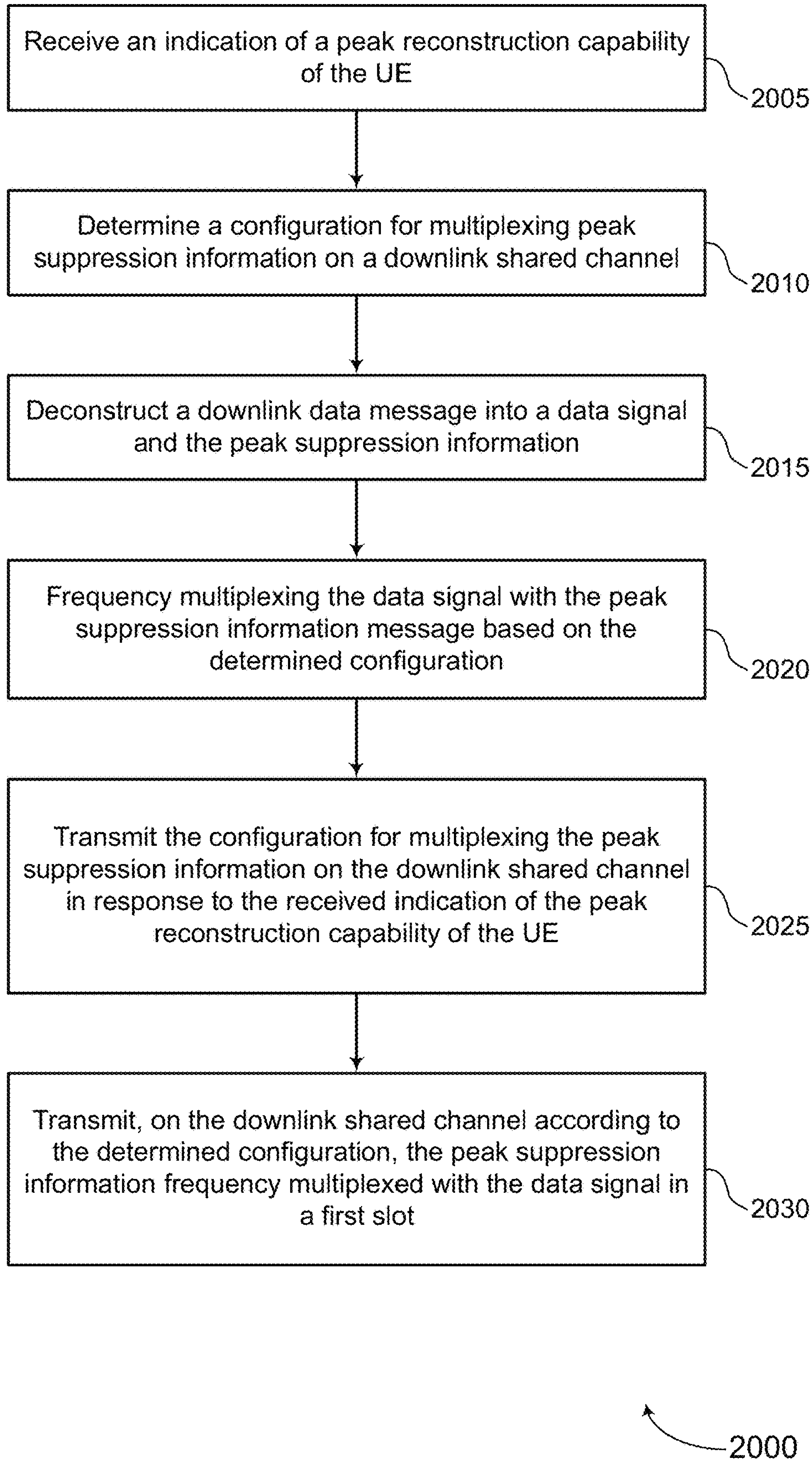

Receive an indication of a peak reconstruction capability of the UE
2005
Determine a configuration for multiplexing peak suppression information on a downlink shared channel
2010
Deconstruct a downlink data message into a data signal and the peak suppression information
2015
Frequency multiplexing the data signal with the peak suppression information message based on the determined configuration
2020
Transmit the configuration for multiplexing the peak suppression information on the downlink shared channel in response to the received indication of the peak reconstruction capability of the UE
2025
Transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot
2030
2000

Figure 20

PEAK SUPPRESSION INFORMATION MULTIPLEXING ON DOWNLINK SHARED CHANNEL

CROSS REFERENCE

The present Application for Patent claims the benefit of U.S. Provisional Patent Application No. 63/010,494 by EGER et al., entitled "PEAK SUPPRESSION INFORMATION MULTIPLEXING ON DOWNLINK SHARED CHANNEL," filed Apr. 15, 2020, assigned to the assignee hereof, and expressly incorporated by reference in its entirety herein.

TECHNICAL FIELD

The following relates generally to wireless communications and more specifically to generating peak suppression information associated with reducing amplitudes of a data signal and multiplexing the peak suppression information with data in a downlink shared channel.

DESCRIPTION OF THE RELATED TECHNOLOGY

Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be capable of supporting communication with multiple users by sharing the available system resources (for example, time, frequency, and power). Examples of such multiple-access systems include fourth generation (4G) systems such as Long Term Evolution (LTE) systems, LTE-Advanced (LTE-A) systems, or LTE-A Pro systems, and fifth generation (5G) systems which may be referred to as New Radio (NR) systems. These systems may employ technologies such as code division multiple access (CDMA), time division multiple access (TDMA), frequency division multiple access (FDMA), orthogonal frequency division multiple access (OFDMA), or discrete Fourier transform spread orthogonal frequency division multiplexing (DFT-S-OFDM). A wireless multiple-access communications system may include one or more base stations or one or more network access nodes, each simultaneously supporting communication for multiple communication devices, which may be otherwise known as user equipment (UE).

A signal transmitted by a base station to a UE may have an associated peak to average power ratio (PAPR). As PAPR increases, the efficiency of a power amplifier (PA) amplifying the signal (for example, a ratio of an output power to an input power for the PA) may decrease. Base stations whose PAs have a decreased efficiency may consume more power or have other performance drawbacks.

SUMMARY

Various aspects relate generally to multiplexing peak suppression information on a downlink shared channel. Generally, the described techniques enable efficient peak to average power ratio (PAPR) reduction via multiplexing peak suppression information message (PSIM) with data on a physical downlink shared channel (PDSCH), or other downlink data or shared (data and control) channel. In some aspects, a base station may clip peaks or otherwise reduce the amplitudes of data samples of a downlink data signal to be transmitted via symbols of a PDSCH to reduce the PAPR of the downlink transmission. For example, a base station may perform an inverse fast Fourier transform (IFFT) on a modulated symbol of a downlink data message to transform the downlink data message in the frequency domain to a time-domain data signal. In the time domain, the base station may then clip, chop off, or otherwise reduce the amplitude peaks of the data signal that exceed a clipping threshold or an amplitude peak threshold (for example, the base station may clip amplitudes of samples of the data signal that are significantly higher than an average power of the data signal). The base station may generate a PSIM based on the clipping that includes amplitude information, position information, or phase information associated with the clipped amplitude peaks of the data signal. A UE receiving the PDSCH, including the symbols containing the data of the clipped data signal as well as the PSIM, may reconstruct the downlink data message based on the received data and the peak suppression information.

In some examples, the base station may multiplex the PSIM with the other unclipped data in the same PDSCH symbol. In some other examples, the base station may multiplex the PSIM with other data in a subsequent symbol of the PDSCH. More specifically, in such latter examples, each PDSCH symbol may include data in addition to a PSIM for a previous PDSCH symbol. For example, a data signal segment in the time domain for a symbol N may include a data message for the symbol N as well as a PSIM for the data signal segment corresponding to the previous symbol N−1. In this manner, causality is preserved when multiplexing the PSIM and data for each PDSCH symbol. As used herein, a data signal segment may refer to a portion or segment of a PDSCH signal corresponding to a symbol (for example, a data signal segment may refer to a time-domain data signal, over the duration of a symbol duration, resulting from a modulated symbol of a downlink data message on the PDSCH).

Various aspects also relate to configurations for multiplexing peak suppression information on a downlink shared channel. For example, a base station may configure time and frequency resources for multiplexing a PSIM, such as by indicating patterns of resource elements (REs) for carrying the peak suppression information. The base station also may configure various other parameters for multiplexing the peak suppression information such as, for example, downlink PSIM modulation, downlink PSIM channel coding, and downlink PSIM multiple-input multiple-output (MIMO) configurations, among other examples. In some example, the base station may configure the UE for such peak suppression information multiplexing on a PDSCH via a physical downlink control channel (PDCCH). A receiving device (for example, the UE) may thus determine a configuration used by the base station for frequency multiplexing of peak suppression information and may reconstruct downlink data messages in accordance with PSIMs multiplexed on the PDSCH.

A method of wireless communication at a UE is described. The method may include determining a configuration for frequency multiplexing peak suppression information on a downlink shared channel, receiving, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot, reconstructing a downlink data message based on the received data signal and the received peak suppression information, and decoding the reconstructed downlink data message.

An apparatus for wireless communication at a UE is described. The apparatus may include a processor, memory coupled with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel, receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot, reconstruct a downlink data message based on the received data signal and the received peak suppression information, and decode the reconstructed downlink data message.

Another apparatus for wireless communication at a UE is described. The apparatus may include means for determining a configuration for frequency multiplexing peak suppression information on a downlink shared channel, receiving, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot, reconstructing a downlink data message based on the received data signal and the received peak suppression information, and decoding the reconstructed downlink data message.

A non-transitory computer-readable medium storing code for wireless communication at a UE is described. The code may include instructions executable by a processor to determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel, receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot, reconstruct a downlink data message based on the received data signal and the received peak suppression information, and decode the reconstructed downlink data message.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the configuration for frequency multiplexing the peak suppression information on the downlink shared channel indicates a pattern of resource elements for the peak suppression information on the downlink shared channel. In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the pattern of resource elements for the peak suppression information uniformly positions the resource elements across frequency on the downlink shared channel. In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, reconstructing the downlink data message may include operations, features, means, or instructions for reconstructing the downlink data message based on the data signal received in a first symbol duration of the downlink shared channel and the peak suppression information received in a second symbol duration of the downlink shared channel, the second symbol duration after the first symbol duration.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, reconstructing the downlink data message may include operations, features, means, or instructions for reconstructing the downlink data message based on the peak suppression information received in a first symbol duration of the downlink shared channel and the data signal received in a second symbol duration of the downlink shared channel, the second symbol duration after the first symbol duration. In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, reconstructing the downlink data message may include operations, features, means, or instructions for reconstructing the downlink data message based on the data signal received in a same symbol duration of the downlink shared channel as the peak suppression information.

A method of wireless communication at a base station is described. The method may include determining a configuration for multiplexing peak suppression information on a downlink shared channel, deconstructing a downlink data message into a data signal and the peak suppression information, frequency multiplexing the data signal with the peak suppression information based on the determined configuration, and transmitting, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

An apparatus for wireless communication at a base station is described. The apparatus may include a processor, memory coupled with the processor, and instructions stored in the memory. The instructions may be executable by the processor to cause the apparatus to determine a configuration for multiplexing peak suppression information on a downlink shared channel, deconstruct a downlink data message into a data signal and the peak suppression information, frequency multiplexing the data signal with the peak suppression information based on the determined configuration, and transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

Another apparatus for wireless communication at a base station is described. The apparatus may include means for determining a configuration for multiplexing peak suppression information on a downlink shared channel, deconstructing a downlink data message into a data signal and the peak suppression information, frequency multiplexing the data signal with the peak suppression information based on the determined configuration, and transmitting, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

A non-transitory computer-readable medium storing code for wireless communication at a base station is described. The code may include instructions executable by a processor to determine a configuration for multiplexing peak suppression information on a downlink shared channel, deconstruct a downlink data message into a data signal and the peak suppression information, frequency multiplexing the data signal with the peak suppression information based on the determined configuration, and transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the configuration for frequency multiplexing the peak suppression information on the downlink shared channel indicates a pattern of resource elements for the peak suppression information on the downlink shared channel. In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, the pattern of resource elements for the peak suppression information uniformly positions the resource elements across frequency on the downlink shared channel.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, multiplexing the data signal with the peak suppression information may include operations, features, means, or instructions for multiplexing, based on the configuration, the peak suppression information associated with a first symbol duration of the downlink shared channel with the data signal associated with a second symbol duration of the downlink shared channel, the first symbol duration after the second symbol duration.

In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, multiplexing the data signal with the peak suppression information may include operations, features, means, or instructions for multiplexing, based on the configuration, the data signal associated with a first symbol duration of the downlink shared channel with the peak suppression information associated with a second symbol duration of the downlink shared channel, the first symbol duration after the second symbol duration. In some examples of the method, apparatuses, and non-transitory computer-readable medium described herein, deconstructing the downlink data message may include operations, features, means, or instructions for deconstructing the downlink data message based on the data signal transmitted in a same symbol duration of the downlink shared channel as the peak suppression information.

BRIEF DESCRIPTION OF THE DRAWINGS

Details of one or more implementations of the subject matter described in this disclosure are set forth in the accompanying drawings and the description below. Other features, aspects, and advantages will become apparent from the description, the drawings and the claims. Note that the relative dimensions of the following figures may not be drawn to scale.

FIGS. **1** and **2** illustrate examples of wireless communications systems that support peak suppression information message (PSIM) multiplexing on a physical downlink shared channel (PDSCH) in accordance with one or more aspects of the present disclosure.

FIG. **3** illustrates an example of a data signal processing chain that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **4**A illustrates an example of a data signal that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **4**B illustrates an example of a clipped data signal that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **5** illustrates an example of a data signal that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **6** illustrates an example of a data signal processing chain that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **7** illustrates an example of a multiplexing configuration that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **8** illustrates an example of a process flow that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIGS. **9** and **10** show block diagrams of devices that support PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **11** shows a block diagram of a communications manager that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **12** shows a diagram of a system including a device that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIGS. **13** and **14** show block diagrams of devices that support PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **15** shows a block diagram of a communications manager that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIG. **16** shows a diagram of a system including a device that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

FIGS. **17** through **20** show flowcharts illustrating methods that support PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure.

Like reference numbers and designations in the various drawings indicate like elements.

DETAILED DESCRIPTION

Some wireless communications systems (for example, % New Radio (NR) systems) may support higher-order constellations (such as 256 quadrature amplitude modulation (QAM), 1024 QAM, 4K QAM, or 16K QAM, among other examples) which have a low error vector magnitude (EVM) threshold for accurate data recovery. EVM may refer to a measure of the distance between the points on a constellation and their ideal locations. As each constellation point may represent a different phase and amplitude combination, higher-order constellations may thus use a power amplifier (PA) of a transmitter to have an operating range large enough to represent the range of amplitudes in a data signal to be transmitted (for example, in order to ensure low EVM). However, orthogonal frequency division multiple access (OFDMA) signaling techniques may tend to yield high peak-to-average power ratios (PAPRs) compared to single-carrier signaling techniques, which may significantly increase power consumption of the PA at the transmitter or reduce the efficiency of the PA at the transmitter, among other examples.

Various aspects relate generally to multiplexing peak suppression information on a downlink shared channel. Some particular aspects enable PAPR reduction while maintaining network efficiency and avoiding increasing latency. In some examples, a base station may multiplex a peak suppression information message (PSIM) with data on a physical downlink shared channel (PDSCH). In some aspects, to reduce PAPR, base station may clip peaks corresponding to data samples of a time-domain data signal to reduce the amplitudes associated with the respective data samples such that they are below a clipping threshold or peak amplitude threshold. For example, a base station may perform an inverse fast Fourier transform (IFFT) on a frequency domain representation of a data message to obtain a time-domain data signal that includes data samples representing the data message in the time domain. The base station may then clip or remove peaks of the time-domain data signal by reducing the amplitudes of the respective data samples to below the clipping threshold or peak amplitude threshold. In some examples, the base station may subtract a portion of the amplitude of a peak to reduce the amplitude to below the clipping threshold. In some other examples, the base station may remove a peak amplitude entirely and replace the amplitude of the data sample with another amplitude, which may have a determined value, that is below the clipping threshold.

Along with clipping the peaks, the base station also generates peak suppression information associated with the clipped peaks, and transmits a PSIM that includes the peak suppression information to a UE. The peak suppression information may include amplitude information as well as position information and phase information associated with the clipped amplitude peaks of the transmitted data signal. The peak suppression information enables the UE to reconstruct the original time-domain data signal from the clipped version, and ultimately reconstruct the downlink data message.

In some examples, the base station may multiplex the PSIM with the other unclipped data in the same PDSCH symbol. In some other examples, the base station may multiplex the PSIM with other data in a subsequent symbol of the PDSCH. More specifically, in such latter examples, each PDSCH symbol may include data in addition to a PSIM for a previous PDSCH symbol. For example, a data signal segment in the time domain for a symbol N may include a data message for the symbol N as well as a PSIM for the data signal segment corresponding to the previous symbol N−1. In this manner, causality is preserved if multiplexing the PSIM and data for each PDSCH symbol.

Various aspects also relate to configurations for multiplexing peak suppression information on a downlink shared channel. For example, a base station may use time and frequency resources for multiplexing a PSIM. The base station may also configure a UE with the time and frequency resources used by the bases station to multiplex the PSIM, such as by indicating patterns of resource elements (REs) for carrying the peak suppression information, so that the UE may receive the PSIM and associated data in a PDSCH. The base station also may configure the UE with various other parameters used by the base station for multiplexing the peak suppression information such as, for example, downlink PSIM modulation, downlink PSIM channel coding, and downlink PSIM multiple-input multiple-output (MIMO) configurations, among other examples. In some examples, the base station may configure the UE for peak suppression information multiplexing on a PDSCH via signaling on a physical downlink control channel (PDCCH).

Particular aspects of the subject matter described in this disclosure may be implemented to realize one or more of the following potential advantages The techniques employed by the described communications devices may allow a base stations to more efficiently employ OFDMA and higher-order constellations. In some aspects, by reducing the PAPR associated with transmitting a data message, and by multiplexing peak suppression information with other data, a base station may efficiently reduce EVMs and power consumption for downlink communications.

Aspects of the disclosure are initially described in the context of example wireless communications systems. Example data signal processing chains, example data signals and example clipped data signals, an example multiplexing configuration, and an example process flow each illustrating one or more aspects of the discussed techniques are then described. Aspects of the disclosure are further illustrated by and described with reference to apparatus diagrams, system diagrams, and flowcharts that relate to PSIM multiplexing on a PDSCH.

FIG. **1** illustrates an example of a wireless communications system **100** in accordance with aspects of the present disclosure. The wireless communications system **100** may include one or more base stations **105**, one or more UEs **115**, and a core network **130**. In some examples, the wireless communications system **100** may be a Long Term Evolution (LTE) network, an LTE-Advanced (LTE-A) network, an LTE-A Pro network, or a New Radio (NR) network. In some examples, the wireless communications system **100** may support enhanced broadband communications, ultra-reliable (for example, mission critical) communications, low latency communications, communications with low-cost and low-complexity devices, or any combination thereof.

The base stations **105** may be dispersed throughout a geographic area to form the wireless communications system **100** and may be devices in different forms or having different capabilities. The base stations **105** and the UEs **115** may wirelessly communicate via one or more communication links **125**. Each base station **105** may provide a coverage area **110** over which the UEs **115** and the base station **105** may establish one or more communication links **125**. The coverage area **110** may be an example of a geographic area over which a base station **105** and a UE **115** may support the communication of signals according to one or more radio access technologies.

The UEs **115** may be dispersed throughout a coverage area **110** of the wireless communications system **100**, and each UE **115** may be stationary, or mobile, or both at different times. The UEs **115** may be devices in different forms or having different capabilities. Some example UEs **115** are illustrated with reference to FIG. **1**. The UEs **115** described herein may be able to communicate with various types of devices, such as other UEs **115**, the base stations **105**, or network equipment (for example, core network nodes, relay devices, integrated access and backhaul (IAB) nodes, or other network equipment), as shown with reference to FIG. **1**.

The base stations **105** may communicate with the core network **130**, or with one another, or both. For example, the base stations **105** may interface with the core network **130** through one or more backhaul links **120** (for example, via an S1, N2, N3, or other interface). The base stations **105** may communicate with one another over the backhaul links **120** (for example, via an X2, Xn, or other interface) either directly (for example, directly between base stations **105**), or indirectly (for example, via core network **130**), or both. In some examples, the backhaul links **120** may be or include one or more wireless links.

One or more of the base stations **105** described herein may include or may be referred to by a person having ordinary skill in the art as a base transceiver station, a radio base station, an access point, a radio transceiver, a NodeB, an eNodeB (eNB), a next-generation NodeB or a giga-NodeB (either of which may be referred to as a gNB), a Home NodeB, a Home eNodeB, or other suitable terminology.

A UE **115** may include or may be referred to as a mobile device, a wireless device, a remote device, a handheld device, or a subscriber device, or some other suitable terminology, in which the "device" may also be referred to as a unit, a station, a terminal, or a client, among other examples. A UE **115** may also include or may be referred to as a personal electronic device such as a cellular phone, a personal digital assistant (PDA), a tablet computer, a laptop computer, or a personal computer. In some examples, a UE **115** may include or be referred to as a wireless local loop (WLL) station, an Internet of Things (IoT) device, an Internet of Everything (IoE) device, or a machine type communications (MTC) device, among other examples, which may be implemented in various objects such as appliances, or vehicles, meters, among other examples.

The UEs **115** described herein may be able to communicate with various types of devices, such as other UEs **115** that may sometimes act as relays as well as the base stations

105 and the network equipment including macro eNBs or gNBs, small cell eNBs or gNBs, or relay base stations, among other examples, as shown with reference to FIG. 1.

The UEs **115** and the base stations **105** may wirelessly communicate with one another via one or more communication links **125** over one or more carriers. The term "carrier" may refer to a set of radio frequency spectrum resources having a defined physical layer structure for supporting the communication links **125**. For example, a carrier used for a communication link **125** may include a portion of a radio frequency spectrum band (for example, a bandwidth part (BWP)) that is operated according to one or more physical layer channels for a given radio access technology (for example, LTE, LTE-A, LTE-A Pro, NR). Each physical layer channel may carry acquisition signaling (for example, synchronization signals, system information), control signaling that coordinates operation for the carrier, user data, or other signaling. The wireless communications system **100** may support communication with a UE **115** using carrier aggregation or multi-carrier operation. A UE **115** may be configured with multiple downlink component carriers and one or more uplink component carriers according to a carrier aggregation configuration. Carrier aggregation may be used with both frequency division duplexing (FDD) and time division duplexing (TDD) component carriers.

Signal waveforms transmitted over a carrier may be made up of multiple subcarriers (for example, using multi-carrier modulation (MCM) techniques such as orthogonal frequency division multiplexing (OFDM) or discrete Fourier transform spread OFDM (DFT-S-OFDM)). In a system employing MCM techniques, a resource element may consist of one symbol duration (for example, a duration of one modulation symbol) and one subcarrier, in which the symbol duration and subcarrier spacing are inversely related. The number of bits carried by each resource element may depend on the modulation scheme (for example, the order of the modulation scheme, the coding rate of the modulation scheme, or both). Thus, the more resource elements that a UE **115** receives and the higher the order of the modulation scheme, the higher the data rate may be for the UE **115**. A wireless communications resource may refer to a combination of a radio frequency spectrum resource, a time resource, and a spatial resource (for example, spatial layers or beams), and the use of multiple spatial layers may further increase the data rate or data integrity for communications with a UE **115**.

The time intervals for the base stations **105** or the UEs **115** may be expressed in multiples of a basic time unit which may, for example, refer to a sampling duration of $T_s=1/(\Delta f_{max} \cdot N_f)$ seconds, in which Δf_{max} may represent the maximum supported subcarrier spacing, and N_f may represent the maximum supported discrete Fourier transform (DFT) size. Time intervals of a communications resource may be organized according to radio frames each having a specified duration (for example, 10 milliseconds (ms)). Each radio frame may be identified by a system frame number (SFN) (for example, ranging from 0 to 1023).

Each frame may include multiple consecutively numbered subframes or slots, and each subframe or slot may have the same duration. In some examples, a frame may be divided (for example, in the time domain) into subframes, and each subframe may be further divided into a number of slots. Alternatively, each frame may include a variable number of slots, and the number of slots may depend on subcarrier spacing. Each slot may include a number of symbol durations (for example, depending on the length of the cyclic prefix prepended to each symbol duration). In some wireless communications systems **100**, a slot may further be divided into multiple mini-slots containing one or more symbols. Excluding the cyclic prefix, each symbol duration may contain one or more (for example, N_f) sampling durations. The duration of a symbol duration may depend on the subcarrier spacing or frequency band of operation.

A subframe, a slot, a mini-slot, or a symbol may be the smallest scheduling unit (for example, in the time domain) of the wireless communications system **100** and may be referred to as a transmission time interval (TTI). In some examples, the TTI duration (for example, the number of symbol durations in a TTI) may be variable. Additionally or alternatively, the smallest scheduling unit of the wireless communications system **100** may be dynamically selected (for example, in bursts of shortened TTIs (sTTIs)).

Physical channels may be multiplexed on a carrier according to various techniques. A physical control channel and a physical data channel may be multiplexed on a downlink carrier, for example, using one or more of time division multiplexing (TDM) techniques, frequency division multiplexing (FDM) techniques, or hybrid TDM-FDM techniques. A control region (for example, a control resource set (CORESET)) for a physical control channel may be defined by a number of symbol durations and may extend across the system bandwidth or a subset of the system bandwidth of the carrier. One or more control regions (for example, CORESETs) may be configured for a set of the UEs **115**. For example, one or more of the UEs **115** may monitor or search control regions for control information according to one or more search space sets, and each search space set may include one or multiple control channel candidates in one or more aggregation levels arranged in a cascaded manner. An aggregation level for a control channel candidate may refer to a number of control channel resources (for example, control channel elements (CCEs)) associated with encoded information for a control information format having a given payload size. Search space sets may include common search space sets configured for sending control information to multiple UEs **115** and UE-specific search space sets for sending control information to a specific UE **115**.

In some examples, a base station **105** may be movable and therefore provide communication coverage for a moving geographic coverage area **110**. In some examples, different geographic coverage areas **110** associated with different technologies may overlap, but the different geographic coverage areas **110** may be supported by the same base station **105**. In other examples, the overlapping geographic coverage areas **110** associated with different technologies may be supported by different base stations **105**. The wireless communications system **100** may include, for example, a heterogeneous network in which different types of the base stations **105** provide coverage for various geographic coverage areas **110** using the same or different radio access technologies.

The wireless communications system **100** may be configured to support ultra-reliable communications or low-latency communications, or various combinations thereof. For example, the wireless communications system **100** may be configured to support ultra-reliable low-latency communications (URLLC) or mission critical communications. The UEs **115** may be designed to support ultra-reliable, low-latency, or critical functions (for example, mission critical functions). Ultra-reliable communications may include private communication or group communication and may be supported by one or more mission critical services such as mission critical push-to-talk (MCPTT), mission critical video (MCVideo), or mission critical data (MCData). Support for mission critical functions may include prioritization of services, and mission critical services may be used for public safety or general commercial applications. The terms ultra-reliable, low-latency, mission critical, and ultra-reliable low-latency may be used interchangeably herein.

In some examples, a UE **115** may also be able to communicate directly with other UEs **115** over a device-to-device (D2D) communication link **135** (for example, using a peer-to-peer (P2P) or D2D protocol). One or more UEs **115** utilizing D2D communications may be within the geographic coverage area **110** of a base station **105**. Other UEs **115** in such a group may be outside the geographic coverage area **110** of a base station **105** or be otherwise unable to receive transmissions from a base station **105**. In some examples, groups of the UEs **115** communicating via D2D communications may utilize a one-to-many (1:M) system in which each UE **115** transmits to every other UE **115** in the group. In some examples, a base station **105** facilitates the scheduling of resources for D2D communications. In other cases, D2D communications are carried out between the UEs **115** without the involvement of a base station **105**.

The core network **130** may provide user authentication, access authorization, tracking, Internet Protocol (IP) connectivity, and other access, routing, or mobility functions. The core network **130** may be an evolved packet core (EPC) or 5G core (5GC), which may include at least one control plane entity that manages access and mobility (for example, a mobility management entity (MME), an access and mobility management function (AMF)) and at least one user plane entity that routes packets or interconnects to external networks (for example, a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). The control plane entity may manage non-access stratum (NAS) functions such as mobility, authentication, and bearer management for the UEs **115** served by the base stations **105** associated with the core network **130**. User IP packets may be transferred through the user plane entity, which may provide IP address allocation as well as other functions. The user plane entity may be connected to the network operators IP services **150**. The operators IP services **150** may include access to the Internet, Intranet(s), an IP Multimedia Subsystem (IMS), or a Packet-Switched Streaming Service.

Some of the network devices, such as a base station **105**, may include subcomponents such as an access network entity **140**, which may be an example of an access node controller (ANC). Each access network entity **140** may communicate with the UEs **115** through one or more other access network transmission entities **145**, which may be referred to as radio heads, smart radio heads, or transmission/reception points (TRPs). Each access network transmission entity **145** may include one or more antenna panels. In some configurations, various functions of each access network entity **140** or base station **105** may be distributed across various network devices (for example, radio heads and ANCs) or consolidated into a single network device (for example, a base station **105**).

The wireless communications system **100** may operate using one or more frequency bands, typically in the range of 300 megahertz (MHz) to 300 gigahertz (GHz). Generally, the region from 300 MHz to 3 GHz is known as the ultra-high frequency (UHF) region or decimeter band because the wavelengths range from approximately one decimeter to one meter in length. The UHF waves may be blocked or redirected by buildings and environmental features, but the waves may penetrate structures sufficiently for a macro cell to provide service to the UEs **115** located indoors. The transmission of UHF waves may be associated with smaller antennas and shorter ranges (for example, less than 100 kilometers) compared to transmission using the smaller frequencies and longer waves of the high frequency (HF) or very high frequency (VHF) portion of the spectrum below 300 MHz.

The wireless communications system **100** may utilize both licensed and unlicensed radio frequency spectrum bands. For example, the wireless communications system **100** may employ License Assisted Access (LAA), LTE-Unlicensed (LTE-U) radio access technology, or NR technology in an unlicensed band such as the 5 GHz industrial, scientific, and medical (ISM) band. If operating in unlicensed radio frequency spectrum bands, devices such as the base stations **105** and the UEs **115** may employ carrier sensing for collision detection and avoidance. In some examples, operations in unlicensed bands may be based on a carrier aggregation configuration in conjunction with component carriers operating in a licensed band (for example, LAA). Operations in unlicensed spectrum may include downlink transmissions, uplink transmissions, P2P transmissions, or D2D transmissions, among other examples.

A base station **105** or a UE **115** may be equipped with multiple antennas, which may be used to employ techniques such as transmit diversity, receive diversity, multiple-input multiple-output (MIMO) communications, or beamforming. The antennas of a base station **105** or a UE **115** may be located within one or more antenna arrays or antenna panels, which may support MIMO operations or transmit or receive beamforming. For example, one or more base station antennas or antenna arrays may be co-located at an antenna assembly, such as an antenna tower. In some examples, antennas or antenna arrays associated with a base station **105** may be located in diverse geographic locations. A base station **105** may have an antenna array with a number of rows and columns of antenna ports that the base station **105** may use to support beamforming of communications with a UE **115**. Likewise, a UE **115** may have one or more antenna arrays that may support various MIMO or beamforming operations. Additionally or alternatively, an antenna panel may support radio frequency beamforming for a signal transmitted via an antenna port.

Beamforming, which may also be referred to as spatial filtering, directional transmission, or directional reception, is a signal processing technique that may be used at a transmitting device or a receiving device (for example, a base station **105**, a UE **115**) to shape or steer an antenna beam (for example, a transmit beam, a receive beam) along a spatial path between the transmitting device and the receiving device. Beamforming may be achieved by combining the signals communicated via antenna elements of an antenna array such that some signals propagating at particular orientations with respect to an antenna array experience constructive interference while others experience destructive interference. The adjustment of signals communicated via the antenna elements may include a transmitting device or a receiving device applying amplitude offsets, phase offsets, or both to signals carried via the antenna elements associated with the device. The adjustments associated with each of the antenna elements may be defined by a beamforming weight set associated with a particular orientation (for example, with respect to the antenna array of the transmitting device or receiving device, or with respect to some other orientation).

Wireless communications systems are widely deployed to provide various types of communication content such as voice, video, packet data, messaging, broadcast, and so on. These systems may be multiple-access systems capable of supporting communication with multiple users by sharing the available system resources (for example, time, frequency, and power). A wireless network, for example a wireless local area network (WLAN), such as a Wi-Fi (in other words, Institute of Electrical and Electronics Engineers (IEEE) 802.11) network may include an access point (AP) that may communicate with one or more wireless or mobile devices. The AP may be coupled to a network, such as the Internet, and may enable a mobile device to communicate via the network (or communicate with other devices coupled to the access point). A wireless device may communicate with a network device bi-directionally. For example, in a WLAN, a device may communicate with an associated AP via downlink (for example, the communication link from the AP to the device) and uplink (for example, the communication link from the device to the AP). A wireless personal area network (PAN), which may include a Bluetooth connection, may provide for short range wireless connections between two or more paired wireless devices. For example, wireless devices such as cellular phones may utilize wireless PAN communications to exchange information such as audio signals with wireless headsets.

Performing OFDMA may have several advantages. For instance, OFDMA may simplify channel estimation at a receiver (for example, at a UE **115** receiving a signal from a base station **105**). Further, OFDMA may enable additional flexibility in utilizing available time and frequency resources (for example, as compared to single carrier techniques), among other benefits. However, performing OFDMA may also increase signal PAPR (for example, as compared to single carrier techniques). As the PAPR increases, the power efficiency $\mu=P_{out}/P_{in}$ of a PA may exhibit increasingly non-linear behavior at a lower P_{in} (P_{out} may increase less for a proportional increase in P_{in}). For example, for a lower PAPR, the power efficiency may be approximately linear from $P_{in}=0$ to $P_{in}=P_x$ (in which P_x may be referred to as a working point for the lower PAPR). Similarly, for a higher PAPR, the power efficiency may be approximately linear from $P_{in}=0$ to $P_{in}=P_y$ (in which P_y may be referred to as a working point for the higher PAPR), in which $P_x>P_y$. To enhance (for example, maximize) the power efficiency, a PA may be operated with the working point near the non-linear part of the power efficiency curve. Additionally, the rate of change of P_{out} at P_x for the lower PAPR may be higher than the rate of change of P_{out} at P_x for the higher PAPR. The back-off (BO) of P_y (for example, a difference between a saturation power and a P_{out} at P_y) may be larger than the BO of P_x (for example, a difference between the saturation power and a P_{out} at P_x).

That is, as P_{out} is a function of P_{in}, an optimal PA working point may be as close as possible to the nonlinear part of the curve. Hence, in cases of high PAPR a large BO may be implemented in order to have efficient EVM desirable for higher-order constellations. In other words, if PAPR is high, a PA may implement a large BO (for example, from a power saturation level (P_{sat}) to the average power of the signal) from the point at which the curve becomes non-linear. Reducing PAPR may use less BO and enable a working point with a higher power efficiency (for example, an average signal power or working point closer to the nonlinear part of the $\mu=P_{out}/P_{in}$ curve). Thus, with lower PAPR, power consumption may be reduced without compromising EVM. A PA may thus be more efficient under low PAPR as the working point may be closer to the power saturation level (P_{sat}) without compromising less efficient power consumption via additional P_{in}(for example, without the working point passing the non-linear point of the curve). By reducing the PAPR, the PA may operate more efficiently as the PA may achieve higher P_{out} for the same P_{in}, and as a result, reduce power consumption of the receiving device.

As the size of, or a number of points in, a signal constellation increases (for example, 256 QAM to 1024 QAM to 4KQAM to 16KQAM and so on), a transmitter (for example, a base station **105**) may use more power to achieve sufficiently low EVM, which may result in higher power consumption, increased energy cost, and adverse environmental impacts, among other examples. For example, for higher order constellations (for example, 16KQAM) it may be desirable to realize low bit error rates (BERs) to recover information from a data signal (for example, as higher-order constellation points may be represented by more granular differences in phase and amplitude combinations). However, if the transmitter is transmitting a data signal with a higher PAPR at a high P_{in} (for example, to reduce EVM), the power efficiency μ of the PA amplifying the data signal may be lower than that for transmitting a data signal with a lower PAPR at the same P_{in}. As such, methods which reduce the PAPR may enable more efficient power consumption (for example, enable a working point with higher power efficiency) while achieving sufficiently low EVM for maintaining constellations of increasing size (for example, increasing order).

Wireless communications system **100** may support techniques for reducing PAPR. For example, for downlink communications, base stations **105** may reduce PAPR by clipping or chopping off peaks from a data signal (for example, in which each peak of a data signal that is above a clipping threshold may be clipped or chopped off). For example, during data signal processing for downlink communications, a base station **105** may perform an IFFT and clip or remove peaks of the data signal (for example, represented across the time domain after the IFFT) based on some clipping level or peak amplitude threshold. In some implementations, the base station **105** may then fill in the peaks with pre-determined values below the clipping threshold. Additionally, the base station **105** may generate and ultimately transmit a PSIM that includes information about the chopped peaks, which may enable a receiving device (for example, one or more UEs **115**) that receives the clipped data signal to at least partially reconstruct the original data signal (for example, the data signal prior to being clipped) based on information of the PSIM.

According to the techniques described herein, a base station **105** may multiplex PSIMs on a PDSCH with data for efficient implementation of PSIMs for PAPR reduction. A base station **105** may clip peaks from a data signal (for example, peaks from a IFFT of a modulated PDSCH symbol) and capture information of the clipped peaks into a PSIM. The base station **105** may then multiplex the PSIM on the PDSCH such that a receiving device (for example, a UE **115**) may receive the clipped data signal and reconstruct the PDSCH using the PSIM. According to some aspects, each PDSCH symbol may include a PSIM for a previous PDSCH symbol (for example, such that causality is preserved if multiplexing PSIM and data for each PDSCH symbol). Various aspects of the techniques described herein may further provide for PSIM positioning in frequency, PSIM modulation, PSIM channel coding, PSIM multiple-input multiple-output (MIMO) configurations, among other examples. In accordance with these techniques, base stations

105 may more efficiently employ OFDMA and higher-order constellations. For instance, base stations 105 may achieve increased EVM performance and efficient power consumption for downlink communications via improved PAPR resulting from PSIM multiplexing on a PDSCH.

In some examples, UEs 115 may transmit capability information to a base station 105. The capability information may include an indication of peak reconstruction capability, which may include whether or not the UE 115 supports PSIMs or whether or not the UE 115 supports autonomous signal reconstruction (for example, a UE 115 may support or be able to decode PSIMs, however in some implementations the UE 115 may not be capable of autonomously reconstructing the data signal based on the PSIM). In some implementations, a UE 115 may receive from the base station 105, based on the capability information, control signaling indicating a clipping level (for example, or maximum peak amplitude) the base station 105 applied to generate a clipped data signal, as well as a subset of peaks clipped from the data signal (for example, in a PSIM). In some implementations, the control signaling may further include information (for example, a resource element (RE) pattern) indicating a multiplexing configuration for the PSIM (for example, a configuration for frequency multiplexing of the PSIM on a PDSCH). The UE 115 may receive the clipped data signal generated (for example, multiplexed, clipped, among other examples) in accordance with the control signaling in addition to the PSIM, and the UE 115 may reconstruct the data message based on the clipping level and the PSIM.

FIG. 2 illustrates an example of a wireless communications system 200 that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. In some examples, the wireless communications system 200 may implement aspects of a wireless communications system 100. For example, the wireless communications system 200 may include a base station 105 *a* and a UE 115 *a*, which may be examples of a base station 105 or a UE 115 as described with reference to FIG. 1. The wireless communications system 200 may illustrate an example of downlink communications 220 from the base station 105-*a* to the UE 115-*a*. As discussed herein, the base station 105-*a* may multiplex a data message 225 and a PSIM 230 (for example, on a PDSCH).

For instance, the base station 105-*a* may generate a data signal segment 205 with multiple peaks (for example, amplitude peaks) above a clipping threshold 207 (for example, above an amplitude peak threshold). To lower a PAPR of the data signal segment 205 for a symbol (for example, a PDSCH symbol), the base station 105-*a* may clip or chop off peaks of the data signal segment 205 above the clipping threshold 207 and may fill pre-determined values in their place. Performing such a procedure may result in a clipped data signal 210. Further details of the procedure may be described with reference to FIG. 3. The base station 105-*a* may transmit the clipped data signal 210 to the UE 115-*a*. In some implementations, the base station 105-*a* may transmit the clipped data signal 210 via a data channel (for example, a PDSCH).

The UE 115-*a*, upon receiving the clipped data signal 210, may perform one or more procedures to generate (for example, or reconstruct) a reconstructed data signal 215, which may be an approximate reconstruction of the data signal segment 205. The UE 115-*a* may perform such one or more reconstruction procedures as clipped data signals 210 with chopped peaks may have blurrier or less easily decipherable constellations as opposed to reconstructed data signals 215 with reconstructed peaks. In some examples, the one or more reconstruction procedures may involve the UE 115-*a* receiving a PSIM 230 that indicates a location and amplitude of one or more of the clipped or chopped off peaks. In some implementations, the PSIM 230 may further indicate a phase of the one or more clipped or chopped off peaks. In some implementations, the one or more reconstruction procedures may include the UE 115-*a* receiving control signaling indicating a clipping threshold 207. The UE 115-*a* may use the clipped data signal 210, a PSIM 230, and the clipping threshold 207 to generate a reconstructed data signal 215.

Generally, the base station 105-*a* may transmit control signaling via a control channel (for example, a physical downlink control channel (PDCCH) or a dedicated control channel) or in a control message multiplexed on a data channel. The control signaling may indicate a configuration for frequency multiplexing peak suppression information (for example, one or more PSIMs 230) on a PDSCH (for example, the configuration for frequency multiplexing the peak suppression information on the PDSCH may indicate a pattern of REs for the PSIMs 230 on the PDSCH). In some implementations, the control signaling may further include an indication of the clipping threshold 207, an indication that PSIMs 230 are being used, an indication of a quantity or subset of peaks above the clipping threshold 207 included in a PSIM 230, among other examples. As used herein, control signaling may generally refer to PDCCH signaling, downlink control information (DCI), medium access control (MAC) control element (CE) signaling, radio resource control (RRC) signaling, among other examples.

For example, in some implementations (for example, described in more detail herein, such as with reference to FIG. 7), each symbol (for example, each symbol associated with a PDSCH) symbol may include or hold a PSIM 230 for the previous symbol (for example, to preserve causality). For instance, for a first PDSCH symbol, the data signal segment 205 may represent a downlink data message including only a data message 225 (for example, all REs in a first PDSCH symbol may include data). The base station 105-*a* may perform an IFFT of the downlink data message, and clip the peaks of the resulting data signal segment 205 and transmit the clipped data signal 210 to the UE 115-*a* via a first PDSCH symbol. The base station 105-*a* may generate a PSIM 230 including information (for example, position, amplitude, phase) of the clipped peaks of the data signal segment 205 associated with the first PDSCH symbol. The PSIM 230 including information corresponding to the segment of the data signal associated with the first PDSCH symbol may then be multiplexed with a data message 225 in a second or subsequent PDSCH symbol.

As such, for the second PDSCH symbol, data signal segment 205 (the portion or segment of the data signal associated with the second PDSCH symbol) may represent a data message 225 for the second PDSCH symbol multiplexed with a PSIM including information for reconstructing the downlink data message of the first PDSCH symbol. The base station 105-*a* may perform an IFFT of the second PDSCH symbol downlink data message (including PDSCH data of the second PDSCH symbol and a PSIM corresponding to clipped peak information of the first PDSCH symbol), and the base station 105-*a* may clip the peaks of the resulting second PDSCH symbol data signal segment 205 and transmit the clipped data signal 210 to the UE 115-*a* via a second PDSCH symbol. The base station 105-*a* may generate a PSIM 230 including information (for example, position, amplitude, phase) of the clipped peaks of the data signal segment **205** associated with the second PDSCH symbol, and multiplex the PSIM including information corresponding to the data message of the second PDSCH symbol with a data message **225** in a third PDSCH symbol.

That is, the base station **105**-*a* may determine a downlink data message for a symbol and generate (for example, based at least in part on an IFFT) a data signal segment **205** for each symbol. The base station **105**-*a* may clip the peaks off each data signal segment **205** and generate a PSIM **230** including information on the peaks clipped for the data signal segment **205** of each symbol. The base station **105**-*a* may multiplex a generated PSIM **230** on a respective subsequent symbol, such that each multiplexed symbol may then again be clipped while preserving peak suppression information (for example, the PSIM **230**) included in the downlink data message (for example, in the data signal segment **205**) for the previous symbol. One or more aspects of the techniques described herein may provide for handling of peak suppression information associated with a first and last symbol of a PDSCH. However, in general, for intermediate symbols (for example, PDSCH symbols between a first PDSCH symbol and a last PDSCH symbol), data signal segment **205** may represent a downlink data message including a data message **225** for the given symbol N and a PSIM **230** for the previous symbol N−1 (for example, in which the PSIM **230** for the previous symbol N−1 includes peak suppression information for a clipped data signal **210** associated with the symbol N−1).

FIG. **3** illustrates an example of a data signal processing chain **300** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. In some examples, the data signal processing chain **300** may implement aspects of a wireless communications system **100** or a wireless communications system **200**. A transmitting device **305** may be an example of a base station **105** and a receiving device **310** may be an example of a UE **115** as described with reference to FIGS. **1** and **2**. The transmitting device **305** may transmit PDSCH (for example, with PSIM multiplexing on a PDSCH) to the receiving device **310** in accordance with one or more aspects of the techniques described herein.

For instance, the transmitting device **305** may use a modulation component **315** to produce a signal. In some implementations, the modulation component **315** may map symbols stored at the transmitting device **305** to signals of particular amplitude and phase. As such, the modulation component **315** may produce a signal in the frequency domain according to the amplitude and phase associated with each symbol to be transmitted. The modulation component **315** may also apply a precoding matrix to the signal. The modulation component **315** may output the signal to a serial-to-parallel (S/P) component **320**, which may perform serial to parallel conversion on the signal, and may output the converted signal to an IFFT component **325**. The IFFT component **325** may perform an IFFT on the converted signal and may output a data signal segment **205**-*a* to a peak detection and suppression component **330**. In some examples, the data signal segment **205**-*a* may be an example of a data signal segment **205** as described with reference to FIG. **2**. The data signal segment **205**-*a* may have one or more peaks above a clipping threshold **207**-*a*.

The peak detection and suppression component **330** may detect the peaks (for example, amplitude peaks) of the data signal segment **205**-*a*. For instance, the peak detection and suppression component **330** may detect each of the peaks of the data signal segment **205**-*a* and may determine which of the peaks are above the clipping threshold **207**-*a* (for example, above an amplitude peak threshold). Additionally or alternatively, the transmitting device may detect just the peaks that are above the clipping threshold **207**-*a*. In either case, the peak detection and suppression component **330** may clip off the detected peaks of the in-phase quadrature (IQ) samples of the data signal segment **205**-*a* passing the clipping threshold **207**-*a* and may fill pre-determined values in their place to produce a clipped data signal **210**-*a*, which may be an example of a clipped data signal **210** as described with reference to FIG. **2**. The transmitting device **305** may transmit the clipped data signal **210**-*a* to the receiving device **310**.

A PSIM control component **335** may select which peaks of the data signal segment **205**-*a* above the clipping threshold **207**-*a* to indicate to the receiving device **310** via a PSIM. In some implementations, the PSIM control component **335** may select or determine a subset of the peaks clipped from the data signal segment **205**-*a* (for example, a subset of the total number of peaks above the clipping threshold **207**-*a*). The transmitting device **305** may transmit the PSIM to the receiving device **310** after selecting the subset of the peaks clipped from the data signal segment **205**-*a* (for example, the transmitting device **305** may multiplex the PSIM on a PDSCH to the receiving device **310**). The PSIM may indicate each location and amplitude of a clipped peak sample for the subset of the peaks clipped from the data signal segment **205**-*a*. In some implementations, the PSIM may indicate each phase of a clipped peak sample for the subset of the peaks clipped from the data signal segment **205**-*a*.

A peaks signal generator **340** may receive the PSIM, decode the PSIM, and may generate peak signals (for example, signals including the indicated peaks) according to the peak suppression information in the PSIM. In some implementations, the peaks signal generator **340** may apply a fast Fourier transform (FFT) (for example, in conjunction with an FFT component **345**) to the peaks signal. The peaks signal generator **340** or the FFT component **345** may transmit or pass the peaks signal in the frequency domain to an RE demapper **350**. In some implementations, the RE demapper **350** may receive the clipped data signal **210**-*a* and may perform an FFT on the clipped data signal **210**-*a* to acquire the clipped data signal **210**-*a* in the frequency domain. The RE demapper **350** may process a data path of the clipped data signal **210**-*a*, may equalize a channel of the clipped data signal **210**-*a*, may expand the channel of the clipped data signal **210**-*a* to obtain a full channel, and may revert or undo the precoding matrix applied by the modulation component **315**. A signal reconstruction component **355** may combine the clipped data signal **210**-*a* and the peaks signal (for example, after processing the data path chest, equalizing the channel, expanding the channel, and reverting the precoding matrix). In some implementations, the RE demapper **350** may account for a symbol delay in PSIM for a previous data signal segment **205**. The signal reconstruction component **355** may thus include peaks corresponding to the subset of peaks clipped from the data signal segment **205**-*a* (for example, the portion or segment of the data signal associated with a symbol N) and indicated by the PSIM (for example, in which the PSIM may be multiplexed on a symbol N+1), but may appropriately not include the peaks not in the subset.

In cases in which a data signal (for example, a data signal segment **205**-*a*) includes several peaks higher than the average signal power, the data signal may have high PAPR (for example, as described in more detail herein, for example, with reference to FIGS. **4**A and **4**B). As such, a transmitting device **305** (for example, a base station for a PDSCH) may clip or cut off amplitude peaks of the data signal that are above some clipping threshold (for example, to reduce PAPR and further reduce power consumption). However, if a receiving device **310** (for example, a UE) receives the clipped data signal (for example, clipped data signal **210**-*a*), the receiving device **310** may experience bad BER as peak information may be lost as it was clipped from the data signal.

A receiving device **310** may receive both a clipped data signal **210**-*a* as well as a PSIM, such that the receiving device **310** may a reconstruct data signal **215**-*a* for improved demodulation and improved BER. A transmitting device **305** may clip IQ samples that pass a threshold (for example, a clipping threshold or an amplitude peak threshold). Data describing the clipped sample information may be compressed and transmitted in a PSIM. According to the techniques described herein, the PSIM may be multiplexed on a PDSCH for efficient PSIM signaling and thus efficient PAPR reducing techniques. That is, the PSIM multiplexing on PDSCH techniques described herein may provide for reduced overhead for peak suppression information signaling (compared to implementation of PSIM control regions) and may thus provide for efficient PAPR reduction.

For instance, on a data path between a transmitting device **305** and a receiving device **310**, the receiving device **310** may process a data path channel estimation and may equalize the channel. The receiving device **310** may expand the channel (for example, reverting the precoding matrix) to obtain the full channel. The receiving device **310** may decode PSIM and reconstruct clipped samples. The receiving device **310** may then obtain frequency domain descriptions of the clipped samples. As such, the receiving device **310** may add back the missing peak samples resulting in a reconstructed data signal **215**-*a*. The receiving device **310** may reduce the channel and complete data demodulation.

FIGS. **4**A and **4**B illustrates examples of a data signal **400** and a clipped data signal **401**, respectively, in accordance with aspects of the present disclosure. In some examples, the example data signal **400** and the example clipped data signal **401** may implement aspects of a wireless communications system **100** or a wireless communications system **200**. For example, a base station **105** (for example, as described with reference to FIGS. **1** and **2**) may clip a downlink message as illustrated by one or more aspects of the data signal **400** to produce a clipped data signal as illustrated by one or more aspects of the clipped data signal **401**.

FIG. **4**A shows an example data signal **400** usable for communications between wireless communication devices according to some implementations. In some implementations, the data signal **400** may be one example of a data signal segment **205** (for example, as described with reference to FIGS. **2** and **3**). As shown with reference to FIG. **4**A, the average amplitude (A_{avg}) of the data signal **400** may be less than an amplitude threshold **405** (for example, which may be referred to as a peak amplitude threshold, a clipping threshold, a clipping level, among other examples). In some implementations, the amplitude threshold **405** may be determined based on the average amplitude of the data signal **400** and a target or desired PAPR. For example, the amplitude threshold **405** may be chosen as a cut-off for limiting the PAPR of the data signal **400**. However, the data signal **400** may also include a number of peaks **402**. Although only two of the peaks **402** are highlighted in the example of FIG. **4**A, the peaks **402** may include any samples of the data signal **400** having amplitudes that exceed the amplitude threshold **405**. Each peak **402** may have a unique position (s_n) in the data signal **400**, an amplitude (A_n), and a phase (not shown for simplicity). For example, the peak **402** at position s_1 has an amplitude A_1 that is significantly higher than the amplitude threshold **405**. The presence of the peaks **402** may significantly increase the PAPR of the data signal **400**.

In some implementations, a transmitting device (for example, a base station **105**) may be configured to reduce or mitigate the PAPR of the data signal **400** by suppressing the amplitudes of one or more peaks. For example, the peak detection and suppression component **330** may detect one or more peaks in the data signal **400** and generate peak suppression information describing or determining the detected peaks. A base station may generate a PSIM that may include the positions (s_n), amplitudes (A_n), and phases (not shown) of the peaks **402**. In some aspects, the peak suppression information may be provided to an amplitude suppressor of a transmitting device. The amplitude suppressor may adjust the data signal **400** by reducing or suppressing the amplitudes of the samples associated with the peaks. More specifically, the amplitude suppressor may generate an amplitude-suppressed data signal (for example, a clipped data signal **401**) by replacing or substituting each of the peak amplitudes in the data signal **400** with a suppressed amplitude. In some implementations, the suppressed amplitude may be a known or preconfigured amplitude value that is less than or equal to a corresponding amplitude threshold.

FIG. **4**B shows another example clipped data signal **401** usable for communications between wireless communication devices according to some implementations. In some implementations, the clipped data signal **401** may be one example of the clipped data signal **210** (for example, of FIGS. **2** and **3**). More specifically, the clipped data signal **401** may be an example of the data signal **400**, of FIG. **4**A, after suppressing the amplitudes of the peaks **402**. Compared to the data signal **400** of FIG. **4**A, the amplitude of the clipped data signal **401** may not exceeds the amplitude threshold **405**. More specifically, the amplitude of each of the peaks **402** may be reduced to a suppressed amplitude value (A_s) in the clipped data signal **401**. In some implementations, each of the peaks **402** may be reduced to the same suppressed amplitude value. In some other implementations, different peaks **402** may be reduced to different suppressed amplitude values. The suppressed amplitude values may include any amplitude values less than or equal to the amplitude threshold **405**. As a result, the PAPR of the clipped data signal **401** may be significantly lower than the PAPR of the data signal **400** of FIG. **4**A.

Chopping (or reducing) the peak amplitudes of a data signal may degrade EVM at the transmitter. For example, the EVM of the clipped data signal **401** may be worse than the EVM of the original data signal **400**. In some implementations, the base station may provide or otherwise indicate the peak suppression information to the receiving device (for example, the UE) to compensate for the degradation in EVM of the clipped data signal **401**. For example, the PSIM control component **335** may generate a PSIM based on the peak suppression information. In some aspects, the PSIM may include raw data representative of the peak suppression information (for example, including the position, amplitude, and phase of each peak).

In some aspects, the PSIM may be compressed. For example, it is noted that an amplitude suppressor (for example, a clipper) may not alter the phases of the data signal **400** if generating the clipped data signal **401**. Accordingly, in some implementations, the phase information may be excluded from the PSIM to reduce the overhead of the message. The peak amplitudes also may be represented as polar amplitudes in the PSIM. By using the polar notation, the amplitudes of the peaks may be reduced without changing their phases. Other suitable compression techniques may include, but are not limited to, wavelet compression, per-antenna representation of the position of each peak, analog coding, and limiting the peak position vector to a number of known options. In some implementations, the PSIM control component **335** may compress the peak suppression information by quantizing the peak amplitudes into one or more quantization levels.

FIG. **5** illustrates an example of a data signal **500** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. In some examples, the data signal **500** may implement aspects of a wireless communications system **100** or a wireless communications system **200**. For example, a base station **105** (for example, as described with reference to FIGS. **1** and **2**) may clip a downlink message as illustrated by one or more aspects of the data signal **500**. In some implementations, the data signal **500** may be one example of a data signal segment **205** or a data signal **400** (for example, as described with reference to FIGS. **2**, **3**, and **4**A). As shown with reference to FIG. **5**, the average amplitude (A_{avg}) of the data signal **500** may be less than various amplitude thresholds (Amp $Thresh_0$, Amp $Thresh_1$, Amp $Thresh_2$, and Amp $Thresh_3$) (for example, which may be referred to as peak amplitude thresholds, clipping thresholds, clipping levels, among other examples).

Although only two of the peaks **502** are highlighted in the example of FIG. **5**, the peaks **502** may include any samples of the data signal **500** having amplitudes that satisfy any or some combination of amplitude thresholds (Amp $Thresh_0$, Amp $Thresh_1$, Amp $Thresh_2$, and Amp $Thresh_3$). Each peak **502** may have a unique position (s_n) in the data signal **500**, an amplitude, and a phase. For example, some peaks **502** (for example, amplitude peaks) may have significantly higher amplitude (for example, power amplitude) than any of the amplitude thresholds. The presence of the peaks **502** may increase the PAPR of the data signal **500**. The data signal **500** is shown for illustrative purposes. The techniques described herein may be applicable to other data signals (for example, with varying quantity of the peaks **502**, with varying locations of the peaks **502**, with varying quantity of amplitude thresholds, with varying locations of amplitude thresholds, among other examples) by analogy, without departing from the scope of the present disclosure.

In some implementations, a transmitting device (for example, a base station **105**) may be configured to reduce or mitigate the PAPR of the data signal **500** by suppressing the amplitudes of one or more peaks. For example, the peak detection and suppression component **330** may detect one or more peaks in the data signal **500** and generate peak suppression information describing or determining the detected peaks. A base station may generate a PSIM that may include the positions (s_n), amplitudes (A_n), and phases (not shown) of the peaks **502**. In some aspects, the peak suppression information may be provided to an amplitude suppressor of a transmitting device. The amplitude suppressor may adjust the data signal **500** by reducing or suppressing the amplitudes of the samples associated with the peaks. More specifically, the amplitude suppressor may generate an amplitude-suppressed data signal (for example, a clipped data signal) by replacing or substituting each of the peak amplitudes in the data signal **500** with a suppressed amplitude. In some implementations, the suppressed amplitude may be a known or preconfigured amplitude value that is less than or equal to a corresponding amplitude threshold.

Generation of a PSIM may be divided into two stages. For example, a first stage PSIM generation may ensure significant peaks are included (for example, position, amplitude, or phase information is indicated) in a generated PSIM. Significant peaks may include peaks with a highest power (for example, amplitude peaks above a stage one amplitude threshold), peaks associated with prioritized information, lower amplitude peaks, amplitude peaks within some range, among other examples of selection criteria for the significant peaks. Second stage PSIM generation may include incorporation of residual (for example, or remaining, lower priority, among other examples) peaks. For instance, a base station may determine whether to include all peaks in a PSIM, only stage one peaks in a PSIM, or no PSIM at all (for example, depending on PDSCH resource availability and MCS EVM requirements).

In some examples, signal clipping or PSIM generation may consider multiple amplitude peak thresholds (for example, or clipping levels) such that the peaks **502** that are clipped or included in a PSIM may be configurable based on the various multiple amplitude peak thresholds. For example, in some implementations, significant peaks (for example, highest power amplitude peaks) may include all of the peaks **502** exceeding Amp $Thresh_2$ (for example, such that only the subset of the peaks **502** that exceed Amp $Thresh_2$ may be clipped and included in a PSIM). In other examples, a base station may determine that significant peaks (for example, peaks corresponding to important information) may include all of the peaks **502** between Amp $Thresh_0$ and Amp $Thresh_2$ (for example, such that only the subset of the peaks **502** that are between Amp $Thresh_0$ and Amp $Thresh_2$ may be included in a PSIM, although all of the peaks **502** exceeding Amp $Thresh_0$ may be clipped and it may be left up to the UE to recover the peak information for the peaks **502** exceeding Amp $Thresh_2$ that are not included in the PSIM).

In some implementations, the subset of amplitude peaks **502** that will be clipped and the subset of amplitude peaks **502** that will be included in PSIMs (for example, in which each subset may be based on the same or different amplitude thresholds) may be indicated by the base station to the UEs (for example, via control signaling). As such, UEs may determine how downlink data messages are being clipped by the base station, as well as what peaks (for example, or what subset of clipped peaks, such as what significant peaks) will be included in PSIMs multiplexed on a PDSCH (for example, which may enable autonomous data signal reconstruction at the capable UEs).

In some implementations, the amplitude thresholds (Amp $Thresh_0$, Amp $Thresh_1$, Amp $Thresh_2$, and Amp $Thresh_3$) may be determined based on the average amplitude (A_{avg}) of the data signal **500** and a target or desired PAPR (for example, the smaller amplitude threshold from A_{avg} to which peaks are clipped, the lower PAPR). For example, any of the amplitude thresholds shown may be chosen as a cut-off for limiting the PAPR of the data signal **500** to various levels. In some implementations, the amplitude thresholds (Amp $Thresh_0$, Amp $Thresh_1$, Amp $Thresh_2$, and Amp $Thresh_3$) may be determined based on a target or desired PSIM overhead, a target or desired PSIM reliability, among other examples. For example, significant peaks **502** (for example, the subset of all peaks that are clipped) to be included in PSIMs may be determined based on resource availability or PSIM channel coding (for example, PSIM redundancy). For instance, resource availability (for example, a number of REs available for PSIM in each symbol or in each slot) may determine whether all peaks or whether only a subset of significant peaks are to be included in PSIMs. Further, channel coding (for example, redundancy) of PSIMs may further determine whether all peaks or whether only a subset of significant peaks are to be included in PSIMs (for example, as if PSIM REs are repeated for increased PSIM redundancy and reliability, the number of REs available for less significant peaks may be reduced).

FIG. **6** illustrates an example of a data signal processing chain **600** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. In some examples, the data signal processing chain **600** may implement aspects of a wireless communications system **100** or a wireless communications system **200**. For example a base station **105** (for example, as described with reference to FIGS. **1** and **2**) or a transmitting device (for example, as described with reference to FIG. **3**) may implement one or more aspects of the data signal processing chain **600** to clip a data signal segment **205**-*b* (for example, resulting in a clipped data signal **210**-*b*) and multiplex PSIMs **230**-*a* (for example, PSIM **230**-*a* including position, amplitude, or phase information of samples clipped from data signal segment **205**-*b*) on a PDSCH. In some implementations, the data signal processing chain **600** may illustrate one or more aspects as further described with reference to the data signal processing chain **300**.

A base station may multiplex PSIMs **230**-*a* and data messages **225**-*a* (for example, on a PDSCH) via a multiplexing component **605**. In some examples (for example, with reference to FIG. **7**), the data signal processing chain **600** may illustrate a configuration for frequency multiplexing peak suppression information on the PDSCH in which each PDSCH symbol may include data in addition to a PSIM for a previous PDSCH symbol (for example, such that causality is preserved if multiplexing PSIM and data for each PDSCH symbol). As such, the multiplexing component **605** may multiplex a data message **225**-*a* with a PSIM **230**-*a* corresponding to a clipped data signal (for example, a clipped data message) of a previous slot. In other words, PSIMs **230**-*a* may be multiplexed on the PDSCH according to a one symbol delay.

In some examples, a PSIM control component **335**-*a* may be an example of PSIM control component **335** as described with reference to FIG. **3**. For example, the PSIM control component **335**-*a* may generate and otherwise control PSIMs **230**-*a*. For instance, the PSIM control component **335**-*a* may obtain peaks information from a peak detection and suppression component **330**-*a* and may determine a quantity of peaks (for example, all clipped peaks, a subset of significant peaks, among other examples) to include in a PSIM **230**-*a*. Further, the PSIM control component **335**-*a* may compress and modulate peaks information (for example, into the position(s) of each peak of each symbol, the amplitude(s) of each peak of each symbol, or the phase(s) of each peak of each symbol) such that each PSIM **230**-*a* may include clipping information for a symbol N. The PSIM control component **335**-*a* may delay each PSIM **230**-*a* such that the multiplexing component **605** may multiplex the PSIM **230**-*a* on a subsequent symbol N+1.

In some implementations, generation of a PSIM **230**-*a* may be divided into two stages. For example, a first stage PSIM generation may ensure significant peaks are included (for example, position, amplitude, or phase information is indicated by) in a generated PSIM. Significant peaks may include peaks with the most power (for example, amplitude peaks above some stage one amplitude threshold), peaks associated with prioritized information, lower amplitude peaks, amplitude peaks within some range, among other examples. In cases in which enough resources are available residual peaks (for example, or remaining peaks, peaks with less amplitude relative to a significant subset of peaks, among other examples) may be included in the PSIM **230**-*a*.

After multiplexing the data message **225**-*a* with a PSIM **230**-*a* including clipping information for the previous symbol (symbol N−1), the multiplexing component **605** may output the signal to a S/P component **320**-*a*, which may perform serial to parallel conversion on the signal. The S/P component **320**-*a* may output the converted signal to an IFFT component **325**-*a*. The IFFT component **325**-*a* may perform an IFFT on the converted signal and may output a data signal segment **205**-*b* a to a peak detection and suppression component **330**-*a*. As discussed, in the present example, the data signal segment **205**-*b* may include the data message **225**-*a* (for example, corresponding to a symbol N) multiplexed in frequency with PSIM **230**-*a* (for example, corresponding to symbol N−1). The peak detection and suppression component **330**-*a* may then clip the peaks (for example, the amplitude peaks) off of the data signal segment **205**-*b* and the base station may transmit a clipped data signal **210**-*b* to a UE. The peaks information or clipping information associated with the clipping of the data signal segment **205**-*b* (for example, including the data message **225**-*a* corresponding to a symbol N multiplexed in frequency with the PSIM **230**-*a* corresponding to symbol N−1) may then be included in a next PSIM **230**-*a* to be multiplexed on a subsequent symbol N+1.

In some implementations, if MIMO is employed, PSIM may have the same number of layers as the PDSCH data. In some implementations, the base station may determine the MIMO layer configuration (for example, how PSIMs are implemented across one or more layers of a MIMO layer configuration). In some implementations, a base station may transmit the same PSIM symbols in all layers (for example, the peak suppression information may be repeated across all layers of a MIMO layer configuration) to increase PSIM robustness. In other cases, the base station may transmit the same PSIM in a subset of layers. For instance, in some implementations 4 MIMO layers may be configured, and the 4 MIMO layers may be divided into two sets of 2 layers, in which PSIMs are repeated over each respective set of two layers. For some PSIM MIMO configurations, PSIMs may be divided between layers (for example, similar to PDSCH data). In other words, PSIM may be divided onto each layer of the MIMO configuration (for example, no PSIM repetition across layers, which may result in increased PSIM throughput). In some implementations, if target PAPR is low and number of peaks is large, the PSIM MIMO configuration may be similar to the MIMO configuration for PDSCH. If target PAPR is high and the number of peaks is small, the PSIM MIMO configuration may have less layers than the MIMO configuration for PDSCH.

FIG. **7** illustrates an example of a multiplexing configuration **700** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. In some examples, the multiplexing configuration **700** may implement aspects of a wireless communications system **100** or a wireless communications system **200**. For example, a base station may multiplex peak suppression information on one or more symbols of a PDSCH in accordance with one or more aspects of the multiplexing configuration **700**. Further, a UE may receive, process, and decode the PDSCH in accordance with one or more aspects of the multiplexing configuration **700**. A symbol (for example, symbol 0, symbol 1 . . . symbol N−2, symbol N−1) may be associated with a symbol duration **720** (for example, in the time domain). Further, the multiplexing configuration **700** may illustrate a multiplexing configuration of REs **725** (for example, PDSCH REs **725**). In some examples, an RE **725** may span a symbol duration **720** in the time domain and a sub-carrier in the frequency domain. As described, a configuration for frequency multiplexing peak suppression information on a PDSCH may include a configuration of REs **725** configured for PSIM frequency multiplexed with REs **725** configured for the PDSCH.

Multiplexing peak suppression information on a PDSCH may provide for efficient PAPR reduction techniques (for example, and thus reduced power consumption at a transmitting base station). For instance, in some systems, PSIMs may be implemented or defined as a separate control message (for example, over a separate symbol). For example, a subframe may include 14 symbols, in which a first symbol (symbol 0) may include a PDCCH, a second symbol (symbol 1) may include PSIM, a third symbol (symbol 2) and a twelfth symbol (symbol 11) may include demodulated reference signal (DMRS), and the remaining symbols (symbol 3 through symbol 10, symbol 12 and symbol 13) may include the PDSCH. In some examples, a control region (for example, in a symbol between the PDCCH and the DMRS) may include one or more PSIMs corresponding to modulated PDSCH data symbols that are clipped in the time domain.

However, in examples in which PSIMs are implemented as a separate control message or over a separate symbol (for example, absent the described techniques for peak suppression information multiplexing on a PDSCH), the PSIM may be defined in symbol granularity which may increase overhead in some implementations. In other words, multiplexing peak suppression information multiplexing on a PDSCH may result in less overhead for peak suppression information compared to overhead associated with a dedicated control region over a symbol for PSIM. Further, in cases in which systems that implement PSIMs as a separate control message attempt to frequency division multiplex (FDM) PSIM and a data message, the PSIM may change the peaks picture and thus may make the system not causal. Moreover, in cases in which systems that implement PSIMs as a separate control message or over a separate symbol, the symbol including the PSIMs may not support time domain clipping (for example, as there may be nowhere else configured to include a PSIM for the PSIM symbol) which may result in high PAPR for the PSIMs as a separate control message or over a separate symbol.

As such, the techniques described herein may provide for more efficient implementation of PSIMs via multiplexing of the peak suppression information on a PDSCH (for example, compared to implementation of PSIMs via dedicated control regions). The multiplexing configuration **700** may illustrate one or more aspects of techniques for peak suppression information multiplexing on a PDSCH. Various other configurations for frequency multiplexing peak suppression information on a PDSCH are considered by analogy, without departing from the scope of the present disclosure. For instance, the multiplexing configuration **700** may illustrate a configuration for frequency multiplexing peak suppression information on a PDSCH in which each PDSCH symbol may include data in addition to a PSIM for a previous PDSCH symbol (for example, such that causality is preserved if multiplexing PSIM and data for each PDSCH symbol). However, in other examples, frequency multiplexing of peak suppression information on a PDSCH may be configured such that each PDSCH symbol may include data in addition to a PSIM for that same PDSCH symbol (for example, or in addition to a PSIM for a subsequent PDSCH symbol).

Further, the multiplexing configuration **700** may illustrate a configuration for frequency multiplexing peak suppression information on a PDSCH in which the pattern of REs for the peak suppression information on the PDSCH start at a sub-carrier index 0 and repeat every 12 subcarriers. However, frequency multiplexing of peak suppression information on the PDSCH may be configured with any pattern of REs including different subcarrier offsets (for example, a configured pattern of REs for the peak suppression information on the PDSCH may begin on some indicated subcarrier offset, may be repeated according to any periodicity across sub-carriers in frequency, among other examples).

In some examples (for example, as illustrated in the multiplexing configuration **700**), peak suppression information (for example, PSIMs) may be divided into several REs in the PDSCH. Generally, a base station may indicate (for example, via control signaling) information on whether or not signal clipping and corresponding PSIMs are being implemented, information on the configuration for frequency multiplexing peak suppression information on the PDSCH (for example, such as a pattern of REs for PSIMs, PSIM MCS, PSIM MIMO configuration), among other examples. For example, a PDCCH may include information on PSIM patterns (for example, a pattern of PDSCH REs for PSIMs). In some implementations, PSIM patterns within the PDSCH may be configurable based on target PAPR and target throughput considerations. More aggressive reduction of PAPR may result in more REs used for PSIMs. However, higher throughput targets may result in less REs for PSIM. In some examples, a configuration for frequency multiplexing the peak suppression information on the PDSCH may indicate a pattern of REs for the peak suppression information on the PDSCH. The pattern of REs may be configured based on resource availability (for example, based on how many REs in a symbol or a slot are available for PSIMs), based on channel conditions (for example, the periodicity or spacing of REs for PSIMs may be based on channel conditions or blockers associated with frequency of the channel), among other examples.

To preserve the causality or deterministic ability to reconstruct each PDSCH symbol at a receiving device (for example, at a UE), a transmitting device (for example, a base station) may multiplex a PDSCH such that each symbol holds PSIM for the previous symbol. For instance, each symbol (for example, symbol 0, symbol 1 . . . symbol N−2, symbol N−1) may hold PSIM generated based on the data signal clipping of the previous symbol. For example, symbol 1 may include PSIM for symbol 0 multiplexed with data. At **705**, a base station may perform an IFFT for a modulated symbol 0, clip one or more amplitude peaks from the resulting time-domain data signal, and calculate the PSIM for symbol 0 based on the clipping. The base station may then multiplex the PSIM for symbol 0 with PDSCH data on symbol 1. At **710**, the base station may similarly calculate PSIM for symbol 1 and may multiplex the PSIM for symbol 1 with PDSCH data on symbol 2. At **715**, a base station may perform an IFFT for a modulated symbol N−2, clip one or more amplitude peaks from the resulting time-domain data signal, and calculate the PSIM for symbol N−2 based on the clipping. The base station may then multiplex the PSIM for symbol N−2 with PDSCH data on symbol N−1. As such, the added peaks of a symbol due to the incorporation of PSIM for the previous symbol may be accounted for in the PSIM of the subsequent symbol.

In some implementations, PSIM may be positioned uniformly over frequency (for example, every 12 sub-carriers, although other patterns of REs associated with different periodicities, different spacings, different groupings, among other examples are considered by analogy). In some implementations, each symbol PSIM message me be included in a different transport block (TB) than PDSCH data (for example, such that the PSIM and the PDSCH data may go through a channel decoder at a receiving, device, separately). In other cases, each symbol PSIM message me be included in a same TB as PDSCH data. In some examples, PSIM may share the same MCS of the PDSCH data. In other examples, PSIM may have a different (for example, lower) MCS than the PDSCH data. Further, in some implementations, PSIM channel coding may be different than the PDSCH data (for example, and may have larger redundancy to ensure negligible data detection errors). For instance, in some implementations, channel coding for PSIM may provide for more redundancy such that PSIMs are relatively robust compared to PDSCH data (for example, as PSIM payload may be important for successful decoding of the previous symbol, as without peak information a receiver may be unable to decode the entire previous symbol). In some implementations, channel coding for PSIM may be the same as channel coding for PDSCH data.

Further, a configuration for frequency multiplexing peak suppression information on a PDSCH may specify a location in which PSIM may be located for a last symbol. For instance, as illustrated by the multiplexing configuration **700**, PSIM for a last symbol in a slot (for example, symbol N−1) may not be associated with a subsequent symbol for PSIM multiplexing (for example, as the last symbol in the slot may be the last symbol remaining relative to other symbols of the slot). As such, configuration for frequency multiplexing peak suppression information on a PDSCH may specify a location for the PSIM corresponding to the last symbol. In some implementations, the PSIM corresponding to the last symbol may be located in the PDCCH message, may be multiplexed in the first symbol of a next slot, among other examples. Alternatively, a last symbol may be configured such that the last symbol does not use PSIM (for example, and PSIM for a last symbol may be skipped). In some implementations, an MCS may be placed on the last symbol such that the MCS is associated with less EVM and may be more robust to clipping.

FIG. **8** illustrates an example of a process flow **800** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. In some examples, the process flow **800** may implement aspects of the techniques described with reference to FIGS. **1**-**7**. The process flow **800** may be implemented by a UE **115**-*b* and a base station **105**-*b*, which may be examples of a UE **115** and a base station **105** as described with reference to FIGS. **1** and **2**. In the following description of the process flow **800**, the operations between the UE **115**-*b* and the base station **105**-*b* may be transmitted in a different order than the order shown, or the operations performed by the base station **105**-*b* and the UE **115**-*b* may be performed in different orders or at different times. Certain operations may also be left out of the process flow **800**, or other operations may be added to the process flow **800**. It is to be understood that while the base station **105**-*b* and the UE **115**-*b* are shown performing a number of the operations of process flow **800**, any wireless device may perform the operations shown.

At **805**, the UE **115**-*b* may transmit a capability indication to the base station **105**-*b*. In some implementations, the capability may be a capability of the UE to support (for example, decode) PSIMs, a capability of the UE to perform the peak reconstruction (for example, autonomous reconstruction, or both. The capability indication may include one or more bits indicating if the UE **115**-*a* has such capabilities. In some implementations, the indication may be transmitted via RRC signaling.

At **810**, the base station **105**-*b* may determine a configuration for multiplexing peak suppression information on a PDSCH. For example, the base station **105**-*b* may determine a pattern of REs for the peak suppression information on the PDSCH, in which the configuration for multiplexing peak suppression information on the PDSCH indicates the pattern. The PSIM multiplexing configuration (for example, the configuration for multiplexing peak suppression information on the PDSCH) may be determined based on resource availability (for example, a number of REs available for peak suppression information), PAPR reduction thresholds (for example, one or more amplitude peak thresholds or clipping levels used to clip PDSCH data signals), among other examples. In some implementations, the configuration may be determined based on a MIMO configuration (for example, a number of MIMO layers used for communications with the UE **115**-*b*). In some examples, the configuration may be based on throughput targets, PSIM overhead, among other examples. In some examples, the configuration for multiplexing peak suppression information on a PDSCH may be based on the capability indication received from the UE **115**-*b* at **805**.

At **815**, the base station **105**-*b* may deconstruct a downlink data message into a data signal and the peak suppression information. In other words, the base station **105**-*b* may determine or identify a data message (for example, a data message **225**) and peak suppression information (for example, a PSIM **230**) to be multiplexed in frequency for a PDSCH symbol. In some examples, deconstructing (for example, or determining, identifying, among other examples) a downlink data message into a data signal and the peak suppression information may include clipping a data signal including a data message associated with a symbol N and generating a PSIM for a symbol N+1 (for example, the PSIM including the clipping information for the symbol N).

At **820**, the base station **105**-*b* may multiplex peak suppression information on the PDSCH (for example, the base station **105**-*b* may frequency multiplex the data message with the peak suppression information based at least in part on the configuration determined at **810**). Generally, the multiplexing may include multiplexing the data signal with a PSIM associated with a previous symbol (for example, as described in more detail herein, for example, with reference to FIG. **7**), a PSIM associated with the current symbol, or a PSIM associated with a subsequent symbol.

At **825**, the base station **105**-*b* may transmit control signaling to the UE **115**-*b*. Generally, the control signaling may indicate whether clipping and PSIMs are being implemented, in which PSIMs are located (for example, a pattern of REs for peak suppression information, including an index of a location at which PSIM REs start, an offset of a location at which PSIM REs start, a spacing or periodicity of PSIM REs, among other examples), MCS for PSIMs, channel coding for PSIMs, MIMO configuration for PSIMs, whether PSIM messages will be associated with a same or different TB as PDSCH data, among other examples. Further, in some implementations, the control signaling may indicate a clipping level (for example, one or more peak amplitude thresholds) applied to generate a data signal. In some examples, the control signaling may indicate what clipping information may be including in PSIMs (for example, whether all clipped peaks or a subset of significant clipped peaks will be included in PSIMs). In cases in which a subset of clipping information is included in PSIMs, the base station **105**-*b* may indicate what criteria is used for including clipping information in PSIMs (for example, what peak amplitude thresholds are being used for PSIM generation, what information or frequency range is associated with peaks included in PSIMs, among other examples).

At **830**, the base station **105**-*b* may transmit, on the PDSCH according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot. As such, the UE **115**-*b* may receive, on the PDSCH based at least in part on multiplexing configuration (for example, determined based on control information received at **825**, based on network specification or reconfiguration, or both), the peak suppression information frequency multiplexed with a data signal in the first slot.

At **835**, the UE **115**-*b* may reconstruct a downlink data message (for example, the UE **115**-*b* may determine a reconstructed signal **215**) based at least in part on the received data signal and the received peak suppression information. For example, for some multiplexing configurations, the UE **115**-*b* may reconstruct the downlink data message based at least in part on the data signal received in a first symbol duration of the PDSCH and the peak suppression information received in a second symbol duration of the PDSCH, the second symbol duration after the first symbol duration. For other multiplexing configurations, the UE **115**-*b* may reconstruct the downlink data message based at least in part on the peak suppression information received in a first symbol duration of the PDSCH and the data signal received in a second symbol duration of the PDSCH, the second symbol duration after the first symbol duration. For other multiplexing configurations, the UE **115**-*b* may reconstruct the downlink data message based at least in part on the data signal received in a same symbol duration of the PDSCH as the peak suppression information. At **840**, the UE **115**-*b* may decode the downlink data message reconstructed at **835**.

FIG. **9** shows a block diagram of a device **905** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The device **905** may be an example of aspects of a UE **115**. The device **905** may include a receiver **910**, a communications manager **915**, and a transmitter **920**. The communications manager **915** may be implemented, at least in part, by one or both of a modem and a processor. Each of these components may be in communication with one another (for example, via one or more buses).

The receiver **910** may receive information such as packets, user data, or control information associated with various information channels (for example, control channels, data channels, and information related to PSIM multiplexing on a PDSCH, among other examples). Information may be passed on to other components of the device **905**. The receiver **910** may be an example of aspects of the transceiver **1220** described with reference to FIG. **12**. The receiver **910** may utilize an antenna or a set of antennas.

The communications manager **915** may determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel, receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot, reconstruct a downlink data message based on the received data signal and the received peak suppression information, and decode the reconstructed downlink data message.

The transmitter **920** may transmit data signals generated by other components of the device **905**. In some examples, the transmitter **920** may be collocated with a receiver **910** in a transceiver component. For example, the transmitter **920** may be an example of aspects of the transceiver **1220** described with reference to FIG. **12**. The transmitter **920** may utilize a single antenna or a set of antennas. In some implementations, the transmitter **920** may include or may be coupled with a PA.

The communications manager **915** as described may be implemented to realize one or more potential advantages. Some implementations may allow the device **905** to receive peak suppression information on a downlink shared channel. Based on the techniques for receiving peak suppression information, the device **905** may support reconstructing downlink data signals that have been modified to reduce PAPR. As such, the device **905** may exhibit a decreased signaling overhead, an increased reliability of communications, or an increased efficiency, among other benefits.

FIG. **10** shows a block diagram of a device **1005** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The device **1005** may be an example of aspects of a device **905**, or a UE **115**. The device **1005** may include a receiver **1010**, a communications manager **1015**, and a transmitter **1040**. The communications manager **1015** may be implemented, at least in part, by one or both of a modem and a processor. Each of these components may be in communication with one another (for example, via one or more buses).

The receiver **1010** may receive information such as packets, user data, or control information associated with various information channels (for example, control channels, data channels, and information related to PSIM multiplexing on a PDSCH, among other examples). Information may be passed on to other components of the device **1005**. The receiver **1010** may be an example of aspects of the transceiver **1220** described with reference to FIG. **12**. The receiver **1010** may utilize an antenna or a set of antennas. The communications manager **1015** may include a multiplexing configuration manager **1020**, a PDSCH manager **1025**, a signal reconstruction manager **1030**, and a decoder **1035**.

The multiplexing configuration manager **1020** may determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel. The PDSCH manager **1025** may receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot. The signal reconstruction manager **1030** may reconstruct a downlink data message based on the received data signal and the received peak suppression information. The decoder **1035** may decode the reconstructed downlink data message.

The transmitter **1040** may transmit data signals generated by other components of the device **1005**. In some examples, the transmitter **1040** may be collocated with a receiver **1010** in a transceiver component. For example, the transmitter **1040** may be an example of aspects of the transceiver **1220** described with reference to FIG. **12**. The transmitter **1040** may utilize an antenna or a set of antennas. In some implementations, the transmitter **1040** may include or may be coupled with a PA.

FIG. **11** shows a block diagram of a communications manager **1105** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The communications manager **1105** may include a multiplexing configuration manager **1110**, a PDSCH manager **1115**, a signal reconstruction manager **1120**, a decoder **1125**, a PSIM manager **1130**, and a capability manager **1135**. Each of these components may communicate, directly or indirectly, with one another (for example, via one or more buses).

The multiplexing configuration manager **1110** may determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel. In some examples, the multiplexing configuration manager **1110** may determine that the peak suppression information of a first symbol duration is associated with a different transport block than other peak suppression information of other symbol durations. In some examples, the multiplexing configuration manager **1110** may determine that peak suppression information of a first symbol duration is associated with a same transport block as other peak suppression information of at least one other symbol duration.

In some examples, the multiplexing configuration manager **1110** may determine that a same modulation and coding scheme is used for the peak suppression information and the data signal. In some examples, the multiplexing configuration manager **1110** may determine that a first modulation and coding scheme is used for the peak suppression information and a second modulation and coding scheme is used for the data signal, the first modulation and coding scheme different than the second modulation and coding scheme. In some examples, the multiplexing configuration manager **1110** may determine a first channel coding scheme for the peak suppression information different than a second channel coding scheme for the data signal.

In some examples, the multiplexing configuration manager **1110** may receive the configuration for multiplexing the peak suppression information on the downlink shared channel in response to the transmitted indication of the peak reconstruction capability of the UE. In some examples, the multiplexing configuration manager **1110** may determine, based on the configuration, a location of the peak suppression information corresponding to a last symbol duration of the downlink shared channel. In some examples, the multiplexing configuration manager **1110** may determine, based on the configuration, a modulation and coding scheme for a last symbol duration of the downlink shared channel, in which all resource elements of the last symbol duration of the downlink shared channel include data information based on the determined modulation and coding scheme for the last symbol duration.

In some implementations, the configuration for frequency multiplexing the peak suppression information on the downlink shared channel indicates a pattern of resource elements for the peak suppression information on the downlink shared channel. In some implementations, the pattern of resource elements for the peak suppression information uniformly positions the resource elements across frequency on the downlink shared channel. In some implementations, the first channel coding scheme corresponds to a greater redundancy relative to the second channel coding scheme or a same redundancy relative to the second channel coding scheme.

In some implementations, the peak suppression information of a symbol duration is repeated across all layers of a multiple-input multiple-output layer configuration. In some implementations, the peak suppression information of a symbol duration is repeated across a subset of one or more layers of all layers of a multiple-input multiple-output layer configuration. In some implementations, the location is in a downlink control channel. In some implementations, the location includes a first symbol duration of a second slot associated with the downlink shared channel, the second slot subsequent to the first slot. In some implementations, the location includes the last symbol duration of the downlink shared channel. In some implementations, the peak suppression information includes one or more of amplitude information associated with one or more peaks of the data signal, position information associated with one or more peaks of the data signal, and phase information associated with one or more peaks of the data signal.

The PDSCH manager **1115** may receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot.

The signal reconstruction manager **1120** may reconstruct a downlink data message based on the received data signal and the received peak suppression information. In some examples, the signal reconstruction manager **1120** may reconstruct the downlink data message based on the data signal received in a first symbol duration of the downlink shared channel and the peak suppression information received in a second symbol duration of the downlink shared channel, the second symbol duration after the first symbol duration. In some examples, the signal reconstruction manager **1120** may reconstruct the downlink data message based on the peak suppression information received in a first symbol duration of the downlink shared channel and the data signal received in a second symbol duration of the downlink shared channel, the second symbol duration after the first symbol duration. In some examples, the signal reconstruction manager **1120** may reconstruct the downlink data message based on the data signal received in a same symbol duration of the downlink shared channel as the peak suppression information. The decoder **1125** may decode the reconstructed downlink data message.

The PSIM manager **1130** may determine that the peak suppression information corresponds to a subset of amplitude peaks of the received data signal. In some implementations, the subset of peaks include amplitude peaks of the received data signal above a threshold amplitude.

The capability manager **1135** may transmit an indication of a peak reconstruction capability of the UE.

FIG. **12** shows a diagram of a system including a device **1205** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The device **1205** may be an example of or include the components of device **905**, device **1005**, or a UE **115**. The device **1205** may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including a communications manager **1210**, an I/O controller **1215**, a transceiver **1220**, an antenna **1225**, memory **1230**, and a processor **1240**. These components may be in electronic communication via one or more buses (for example, bus **1245**).

The communications manager **1210** may determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel, receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot, reconstruct a downlink data message based on the received data signal and the received peak suppression information, and decode the reconstructed downlink data message.

The I/O controller **1215** may manage input and output data signals for the device **1205**. The I/O controller **1215** may also manage peripherals not integrated into the device

1205. In some implementations, the I/O controller **1215** may represent a physical connection or port to an external peripheral. In some implementations, the I/O controller **1215** may utilize an operating system such as iOS®, ANDROID®, MS-DOS®, MS-WINDOWS®, OS/2®, UNIX®, LINUX®, or another known operating system. In other cases, the I/O controller **1215** may represent or interact with a modem, a keyboard, a mouse, a touchscreen, or a similar device. In some implementations, the I/O controller **1215** may be implemented as part of a processor. In some implementations, a user may interact with the device **1205** via the I/O controller **1215** or via hardware components controlled by the I/O controller **1215**.

The transceiver **1220** may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver **1220** may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver **1220** may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

In some implementations, the wireless device may include an antenna **1225**. However, in some implementations the device may have more than one antenna **1225**, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

The memory **1230** may include random-access memory (RAM) and read-only memory (ROM). The memory **1230** may store computer-readable, computer-executable code or software **1235** including instructions that, when executed, cause the processor to perform various functions described herein. In some implementations, the memory **1230** may contain, among other things, a basic input/output system (BIOS) which may control basic hardware or software operation such as the interaction with peripheral components or devices.

The processor **1240** may include an intelligent hardware device, (for example, a general-purpose processor, a digital signal processor (DSP), a central processing unit (CPU), a microcontroller, an application-specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor **1240** may be configured to operate a memory array using a memory controller. In other cases, a memory controller may be integrated into the processor **1240**. The processor **1240** may be configured to execute computer-readable instructions stored in a memory (for example, the memory **1230**) to cause the device **1205** to perform various functions (for example, functions or tasks supporting PSIM multiplexing on a PDSCH).

The software **1235** may include instructions to implement aspects of the present disclosure, including instructions to support wireless communications. The software **1235** may be stored in a non-transitory computer-readable medium such as system memory or other type of memory. In some implementations, the software **1235** may not be directly executable by the processor **1240** but may cause a computer (for example, when compiled and executed) to perform functions described herein.

FIG. **13** shows a block diagram of a device **1305** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The device **1305** may be an example of aspects of a base station **105**. The device **1305** may include a receiver **1310**, a communications manager **1315**, and a transmitter **1320**. The communications manager **1315** may be implemented, at least in part, by one or both of a modem and a processor. Each of these components may be in communication with one another (for example, via one or more buses).

The receiver **1310** may receive information such as packets, user data, or control information associated with various information channels (for example, control channels, data channels, and information related to PSIM multiplexing on a PDSCH, among other examples). Information may be passed on to other components of the device **1305**. The receiver **1310** may be an example of aspects of the transceiver **1620** described with reference to FIG. **16**. The receiver **1310** may utilize an antenna or a set of antennas.

The communications manager **1315** may determine a configuration for multiplexing peak suppression information on a downlink shared channel, deconstruct a downlink data message into a data signal and the peak suppression information, frequency multiplexing the data signal with the peak suppression information based on the determined configuration, and transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

The transmitter **1320** may transmit data signals generated by other components of the device **1305**. In some examples, the transmitter **1320** may be collocated with a receiver **1310** in a transceiver component. For example, the transmitter **1320** may be an example of aspects of the transceiver **1620** described with reference to FIG. **16**. The transmitter **1320** may utilize an antenna or a set of antennas. In some implementations, the transmitter **1320** may include or may be coupled with a PA.

FIG. **14** shows a block diagram of a device **1405** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The device **1405** may be an example of aspects of a device **1305**, or a base station **105**. The device **1405** may include a receiver **1410**, a communications manager **1415**, and a transmitter **1440**. The communications manager **1415** may be implemented, at least in part, by one or both of a modem and a processor. Each of these components may be in communication with one another (for example, via one or more buses).

The receiver **1410** may receive information such as packets, user data, or control information associated with various information channels (for example, control channels, data channels, and information related to PSIM multiplexing on a PDSCH, among other examples). Information may be passed on to other components of the device **1405**. The receiver **1410** may be an example of aspects of the transceiver **1620** described with reference to FIG. **16**. The receiver **1410** may utilize an antenna or a set of antennas. The communications manager **1415** may include a multiplexing configuration manager **1420**, a signal clipping manager **1425**, a PDSCH multiplexing manager **1430**, and a PDSCH manager **1435**.

The multiplexing configuration manager **1420** may determine a configuration for multiplexing peak suppression information on a downlink shared channel. The signal clipping manager **1425** may deconstruct a downlink data message into a data signal and the peak suppression information. The PDSCH multiplexing manager **1430** may frequency multiplexing the data signal with the peak suppression information based on the determined configuration. The PDSCH manager **1435** may transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

The transmitter **1440** may transmit data signals generated by other components of the device **1405**. In some examples, the transmitter **1440** may be collocated with a receiver **1410** in a transceiver component. For example, the transmitter **1440** may be an example of aspects of the transceiver **1620** described with reference to FIG. **16**. The transmitter **1440** may utilize an antenna or a set of antennas. In some implementations, the transmitter **1440** may include or may be coupled with a PA.

FIG. **15** shows a block diagram of a communications manager **1505** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The communications manager **1505** may include a multiplexing configuration manager **1510**, a signal clipping manager **1515**, a PDSCH multiplexing manager **1520**, a PDSCH manager **1525**, a PSIM manager **1530**, and an UE capability manager **1535**. Each of these components may communicate, directly or indirectly, with one another (for example, via one or more buses).

The multiplexing configuration manager **1510** may determine a configuration for multiplexing peak suppression information on a downlink shared channel. In some examples, the multiplexing configuration manager **1510** may determine that the peak suppression information of a first symbol duration is associated with a different transport block than other peak suppression information of other symbol durations. In some examples, the multiplexing configuration manager **1510** may determine that the peak suppression information of a first symbol duration is associated with a same transport block as other peak suppression information of other symbol durations. In some examples, the multiplexing configuration manager **1510** may determine that a same modulation and coding scheme is used for the peak suppression information and the data signal. In some examples, the multiplexing configuration manager **1510** may determine that a first modulation and coding scheme is used for the peak suppression information and a second modulation and coding scheme is used for the data signal, the first modulation and coding scheme different than the second modulation and coding scheme.

In some examples, the multiplexing configuration manager **1510** may determine a first channel coding scheme for the peak suppression information different than a second channel coding scheme for the data signal. In some examples, the multiplexing configuration manager **1510** may transmit the configuration for multiplexing the peak suppression information on the downlink shared channel in response to the received indication of the peak reconstruction capability of the UE. In some examples, the multiplexing configuration manager **1510** may determine, based on the configuration, a modulation coding scheme for a last symbol duration of the downlink shared channel, in which all resource elements of the last symbol duration of the downlink shared channel include data information based on the determined modulation and coding scheme for the last symbol duration. In some implementations, the configuration for frequency multiplexing the peak suppression information on the downlink shared channel indicates a pattern of resource elements for the peak suppression information on the downlink shared channel.

In some implementations, the pattern of resource elements for the peak suppression information uniformly positions the resource elements across frequency on the downlink shared channel. In some implementations, the first channel coding scheme corresponds to a greater redundancy relative to the second channel coding scheme or a same redundancy relative to the second channel coding scheme. In some implementations, the peak suppression information of a symbol duration is repeated across all layers of a multiple-input multiple-output layer configuration. In some implementations, the peak suppression information of a symbol duration is repeated across a subset of one or more layers of all layers of a multiple-input multiple-output layer configuration. In some implementations, the peak suppression information includes one or more of amplitude information associated with one or more peaks of the data signal, position information associated with one or more peaks of the data signal, and phase information associated with one or more peaks of the data signal.

The signal clipping manager **1515** may deconstruct a downlink data message into a data signal and the peak suppression information. In some examples, the signal clipping manager **1515** may deconstruct the downlink data message based on the data signal transmitted in a same symbol duration of the downlink shared channel as the peak suppression information.

The PDSCH multiplexing manager **1520** may frequency multiplexing the data signal with the peak suppression information based on the determined configuration. In some examples, the PDSCH multiplexing manager **1520** may multiplex, based on the configuration, the peak suppression information associated with a first symbol duration of the downlink shared channel with the data signal associated with a second symbol duration of the downlink shared channel, the first symbol duration after the second symbol duration. In some examples, the PDSCH multiplexing manager **1520** may multiplex, based on the configuration, the data signal associated with a first symbol duration of the downlink shared channel with the peak suppression information associated with a second symbol duration of the downlink shared channel, the first symbol duration after the second symbol duration.

The PDSCH manager **1525** may transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

The PSIM manager **1530** may determine that the peak suppression information corresponds to a subset of amplitude peaks of the transmitted data signal. In some examples, the PSIM manager **1530** may determine, based on the configuration, a location of the peak suppression information corresponding to a last symbol duration of the downlink shared channel. In some implementations, the subset of peaks include amplitude peaks of the transmitted data signal above a threshold amplitude. In some implementations, the location is in a downlink control channel. In some implementations, the location includes a first symbol duration of a second slot associated with the downlink shared channel, the second slot subsequent to the first slot. In some implementations, the location includes the last symbol duration of the downlink shared channel.

The UE capability manager **1535** may receive an indication of a peak reconstruction capability of the UE.

FIG. **16** shows a diagram of a system including a device **1605** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The device **1605** may be an example of or include the components of device **1305**, device **1405**, or a base station **105**. The device **1605** may include components for bi-directional voice and data communications including components for transmitting and receiving communications, including a communications manager **1610**, a network communications manager **1615**, a transceiver **1620**, an antenna **1625**, memory **1630**, a processor **1640**, and an inter-station communications manager **1645**. These components may be in electronic communication via one or more buses (for example, bus **1650**).

The communications manager **1610** may determine a configuration for multiplexing peak suppression information on a downlink shared channel, deconstruct a downlink data message into a data signal and the peak suppression information, frequency multiplexing the data signal with the peak suppression information based on the determined configuration, and transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

The network communications manager **1615** may manage communications with the core network (for example, via one or more wired backhaul links). For example, the network communications manager **1615** may manage the transfer of data communications for client devices, such as one or more UEs **115**.

The transceiver **1620** may communicate bi-directionally, via one or more antennas, wired, or wireless links as described above. For example, the transceiver **1620** may represent a wireless transceiver and may communicate bi-directionally with another wireless transceiver. The transceiver **1620** may also include a modem to modulate the packets and provide the modulated packets to the antennas for transmission, and to demodulate packets received from the antennas.

In some implementations, the wireless device may include an antenna **1625**. However, in some implementations the device may have more than one antenna **1625**, which may be capable of concurrently transmitting or receiving multiple wireless transmissions.

The memory **1630** may include RAM, ROM, or a combination thereof. The memory **1630** may store computer-readable code or software **1635** including instructions that, when executed by a processor (for example, the processor **1640**) cause the device to perform various functions described herein. In some implementations, the memory **1630** may contain, among other things, a BIOS which may control basic hardware or software operation such as the interaction with peripheral components or devices.

The processor **1640** may include an intelligent hardware device, (for example, a general-purpose processor, a DSP, a CPU, a microcontroller, an ASIC, an FPGA, a programmable logic device, a discrete gate or transistor logic component, a discrete hardware component, or any combination thereof). In some implementations, the processor **1640** may be configured to operate a memory array using a memory controller. In some implementations, a memory controller may be integrated into processor **1640**. The processor **1640** may be configured to execute computer-readable instructions stored in a memory (for example, the memory **1630**) to cause the device **1605** to perform various functions (for example, functions or tasks supporting PSIM multiplexing on a PDSCH).

The inter-station communications manager **1645** may manage communications with other base station **105**, and may include a controller or scheduler for controlling communications with UEs **115** in cooperation with other base stations **105**. For example, the inter-station communications manager **1645** may coordinate scheduling for transmissions to UEs **115** for various interference mitigation techniques such as beamforming or joint transmission. In some examples, the inter-station communications manager **1645** may provide an X2 interface within an LTE/LTE-A wireless communication network technology to provide communication between base stations **105**.

The software **1635** may include instructions to implement aspects of the present disclosure, including instructions to support wireless communications. The software **1635** may be stored in a non-transitory computer-readable medium such as system memory or other type of memory. In some implementations, the software **1635** may not be directly executable by the processor **1640** but may cause a computer (for example, when compiled and executed) to perform functions described herein.

FIG. **17** shows a flowchart illustrating a method **1700** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The operations of method **1700** may be implemented by a UE **115** or its components. For example, the operations of method **1700** may be performed by a communications manager as described with reference to FIGS. **9-12**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the functions described below. Additionally or alternatively, a UE may perform aspects of the functions described below using special-purpose hardware.

At **1705**, the UE may determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel. The operations of **1705** may be performed according to the methods described herein. In some examples, aspects of the operations of **1705** may be performed by a multiplexing configuration manager as described with reference to FIGS. **9-12**.

At **1710**, the UE may receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot. The operations of **1710** may be performed according to the methods described herein. In some examples, aspects of the operations of **1710** may be performed by a PDSCH manager as described with reference to FIGS. **9-12**.

At **1715**, the UE may reconstruct a downlink data message based on the received data signal and the received peak suppression information. The operations of **1715** may be performed according to the methods described herein. In some examples, aspects of the operations of **1715** may be performed by a signal reconstruction manager as described with reference to FIGS. **9-12**.

At **1720**, the UE may decode the reconstructed downlink data message. The operations of **1720** may be performed according to the methods described herein. In some examples, aspects of the operations of **1720** may be performed by a decoder as described with reference to FIGS. **9-12**.

FIG. **18** shows a flowchart illustrating a method **1800** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The operations of method **1800** may be implemented by a UE **115** or its components. For example, the operations of method **1800** may be performed by a communications manager as described with reference to FIGS. **9-12**. In some examples, a UE may execute a set of instructions to control the functional elements of the UE to perform the functions described below. Additionally or alternatively, a UE may perform aspects of the functions described below using special-purpose hardware.

At **1805**, the UE may determine a configuration for frequency multiplexing peak suppression information on a downlink shared channel. The operations of **1805** may be performed according to the methods described herein. In some examples, aspects of the operations of **1805** may be performed by a multiplexing configuration manager as described with reference to FIGS. **9-12**.

At **1810**, the UE may receive, on the downlink shared channel based on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot. The operations of **1810** may be performed according to the methods described herein. In some examples, aspects of the operations of **1810** may be performed by a PDSCH manager as described with reference to FIGS. **9-12**.

At **1815**, the UE may reconstruct a downlink data message based on the data signal received in a first symbol duration of the downlink shared channel and the peak suppression information received in a second symbol duration of the downlink shared channel, the second symbol duration after the first symbol duration. The operations of **1815** may be performed according to the methods described herein. In some examples, aspects of the operations of **1815** may be performed by a signal reconstruction manager as described with reference to FIGS. **9-12**.

At **1820**, the UE may decode the reconstructed downlink data message. The operations of **1820** may be performed according to the methods described herein. In some examples, aspects of the operations of **1820** may be performed by a decoder as described with reference to FIGS. **9-12**.

At **1825**, the UE may determine, based on the configuration, a location of the peak suppression information corresponding to a last symbol duration of the downlink shared channel. The operations of **1825** may be performed according to the methods described herein. In some examples, aspects of the operations of **1825** may be performed by a multiplexing configuration manager as described with reference to FIGS. **9-12**.

FIG. **19** shows a flowchart illustrating a method **1900** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The operations of method **1900** may be implemented by a base station **105** or its components. For example, the operations of method **1900** may be performed by a communications manager as described with reference to FIGS. **13-16**. In some examples, a base station may execute a set of instructions to control the functional elements of the base station to perform the functions described below. Additionally or alternatively, a base station may perform aspects of the functions described below using special-purpose hardware.

At **1905**, the base station may determine a configuration for multiplexing peak suppression information on a downlink shared channel. The operations of **1905** may be performed according to the methods described herein. In some examples, aspects of the operations of **1905** may be performed by a multiplexing configuration manager as described with reference to FIGS. **13-16**.

At **1910**, the base station may deconstruct a downlink data message into a data signal and the peak suppression information. The operations of **1910** may be performed according to the methods described herein. In some examples, aspects of the operations of **1910** may be performed by a signal clipping manager as described with reference to FIGS. **13-16**.

At **1915**, the base station may frequency multiplexing the data signal with the peak suppression information based on the determined configuration. The operations of **1915** may be performed according to the methods described herein. In some examples, aspects of the operations of **1915** may be performed by a PDSCH multiplexing manager as described with reference to FIGS. **13-16**.

At **1920**, the base station may transmit, on the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot. The operations of **1920** may be performed according to the methods described herein. In some examples, aspects of the operations of **1920** may be performed by a PDSCH manager as described with reference to FIGS. **13-16**.

FIG. **20** shows a flowchart illustrating a method **2000** that supports PSIM multiplexing on a PDSCH in accordance with one or more aspects of the present disclosure. The operations of method **2000** may be implemented by a base station **105** or its components. For example, the operations of method **2000** may be performed by a communications manager as described with reference to FIGS. **13-16**. In some examples, a base station may execute a set of instructions to control the functional elements of the base station to perform the functions described below. Additionally or alternatively, a base station may perform aspects of the functions described below using special-purpose hardware.

At **2005**, the base station may receive an indication of a peak reconstruction capability of the UE. The operations of **2005** may be performed according to the methods described herein. In some examples, aspects of the operations of **2005** may be performed by an UE capability manager as described with reference to FIGS. **13-16**.

At **2010**, the base station may determine a configuration for multiplexing peak suppression information on a downlink shared channel. The operations of **2010** may be performed according to the methods described herein. In some examples, aspects of the operations of **2010** may be performed by a multiplexing configuration manager as described with reference to FIGS. **13-16**.

At **2015**, the base station may deconstruct a downlink data message into a data signal and the peak suppression information. The operations of **2015** may be performed according to the methods described herein. In some examples, aspects of the operations of **2015** may be performed by a signal clipping manager as described with reference to FIGS. **13-16**.

At **2020**, the base station may frequency multiplexing the data signal with the peak suppression information based on the determined configuration. The operations of **2020** may be performed according to the methods described herein. In some examples, aspects of the operations of **2020** may be performed by a PDSCH multiplexing manager as described with reference to FIGS. **13-16**.

At **2025**, the base station may transmit the configuration (for example, the configuration for multiplexing the peak suppression information on the downlink shared channel) in response to the received indication of the peak reconstruction capability of the UE. In some implementations, the configuration information may be received via a PDCCH (for example, PDCCH scheduling the PDSCH associated with the PSIM multiplexing). The operations of **2025** may be performed according to the methods described herein. In some examples, aspects of the operations of **2025** may be performed by a multiplexing configuration manager as described with reference to FIGS. **13-16**.

At **2030**, the base station may transmit, on the downlink shared channel (for example, the PDSCH) according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot. The operations of **2030** may be performed according to the methods described herein. In some examples, aspects of the operations of **2030** may be performed by a PDSCH manager as described with reference to FIGS. **13-16**.

It should be noted that the methods described herein describe possible implementations, and that the operations and the steps may be rearranged or otherwise modified and that other implementations are possible. Further, aspects from two or more of the methods may be combined.

Although aspects of an LTE, LTE-A, LTE-A Pro, or NR system may be described for purposes of example, and LTE, LTE-A, LTE-A Pro, or NR terminology may be used in much of the description, the techniques described herein are applicable beyond LTE, LTE-A, LTE-A Pro, or NR networks. For example, the described techniques may be applicable to various other wireless communications systems such as Ultra Mobile Broadband (UMB), Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20, Flash-OFDM, as well as other systems and radio technologies not explicitly mentioned herein.

Information and signals described herein may be represented using any of a variety of different technologies and techniques. For example, data, instructions, commands, information, signals, bits, symbols, and chips that may be referenced throughout the description may be represented by voltages, currents, electromagnetic waves, magnetic fields or particles, optical fields or particles, or any combination thereof.

The various illustrative blocks and components described in connection with the disclosure herein may be implemented or performed with a general-purpose processor, a DSP, an ASIC, a CPU, an FPGA or other programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination thereof designed to perform the functions described herein. A general-purpose processor may be a microprocessor, but in the alternative, the processor may be any processor, controller, microcontroller, or state machine. A processor may also be implemented as a combination of computing devices (for example, a combination of a DSP and a microprocessor, multiple microprocessors, one or more microprocessors in conjunction with a DSP core, or any other such configuration).

The functions described herein may be implemented in hardware, software executed by a processor, firmware, or any combination thereof. If implemented in software executed by a processor, the functions may be stored on or transmitted over as one or more instructions or code on a computer-readable medium. Other examples and implementations are within the scope of the disclosure and appended claims. For example, due to the nature of software, functions described herein may be implemented using software executed by a processor, hardware, firmware, hardwiring, or combinations of any of these. Features implementing functions may also be physically located at different locations, including being distributed such that portions of functions are implemented at different physical locations.

Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special purpose computer. By way of example, and not limitation, non-transitory computer-readable media may include RAM, ROM, electrically erasable programmable ROM (EEPROM), flash memory, compact disk (CD) ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other non-transitory medium that may be used to carry or store desired program code means in the form of instructions or data structures and that may be accessed by a general-purpose or special-purpose computer, or a general-purpose or special-purpose processor. Also, any connection is properly termed a computer-readable medium. For example, if the software is transmitted from a website, server, or other remote source using a coaxial cable, fiber optic cable, twisted pair, digital subscriber line (DSL), or wireless technologies such as infrared, radio, and microwave, then the coaxial cable, fiber optic cable, twisted pair, DSL, or wireless technologies such as infrared, radio, and microwave are included in the definition of computer-readable medium. Disk and disc, as used herein, include CD, laser disc, optical disc, digital versatile disc (DVD), floppy disk and Blu-ray disc in which disks usually reproduce data magnetically, while discs reproduce data optically with lasers. Combinations of the above are also included within the scope of computer-readable media.

As used herein, including in the claims, “or” as used in a list of items (for example, a list of items prefaced by a phrase such as “at least one of” or “one or more of”) indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (in other words, A and B and C). Also, as used herein, the phrase “based on” shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as “based on condition A” may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase “based on” shall be construed in the same manner as the phrase “based at least in part on.”

In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If just the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label, or other subsequent reference label.

The description set forth herein, in connection with the appended drawings, describes example configurations and does not represent all the examples that may be implemented or that are within the scope of the claims. The term “example” used herein means “serving as an example, instance, or illustration,” and not “preferred” or “advantageous over other examples.” The detailed description includes specific details for the purpose of providing an understanding of the described techniques. These techniques, however, may be practiced without these specific details. In some instances, known structures and devices are shown in block diagram form in order to avoid obscuring the concepts of the described examples.

The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein, but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

What is claimed is:

1. A method for wireless communication at a user equipment (UE), comprising:

determining a configuration for frequency multiplexing peak suppression information via a downlink shared channel, the configuration indicating a pattern of resource elements for the peak suppression information via the downlink shared channel;

receiving, via the downlink shared channel based at least in part on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot;

determining that the peak suppression information corresponds to a subset of amplitude peaks of the received data signal above a threshold amplitude;

reconstructing a downlink data message based at least in part on the received data signal and the received peak suppression information; and

decoding the reconstructed downlink data message.

2. The method of claim **1**, wherein the pattern of resource elements for the peak suppression information uniformly positions the resource elements across frequency via the downlink shared channel.

3. The method of claim **1**, wherein reconstructing the downlink data message comprises reconstructing the downlink data message based at least in part on one or more of the data signal being received in a first symbol duration of the downlink shared channel and the peak suppression information being received in a second symbol duration of the downlink shared channel, the second symbol duration after the first symbol duration, or the peak suppression information being received in a first symbol duration of the downlink shared channel and the data signal being received in a second symbol duration of the downlink shared channel, the second symbol duration after the first symbol duration, or the data signal being received in a same symbol duration of the downlink shared channel as the peak suppression information.

4. The method of claim **1**, wherein determining the configuration comprises determining that the peak suppression information of a first symbol duration is associated with a different transport block than other peak suppression information of other symbol durations or determining that the peak suppression information of a first symbol duration is associated with a same transport block as other peak suppression information of at least one other symbol duration.

5. The method of claim **1**, wherein determining the configuration comprises determining that a same modulation and coding scheme is used for the peak suppression information and the received data signal or determining that a first modulation and coding scheme is used for the peak suppression information and a second modulation and coding scheme is used for the received data signal, the first modulation and coding scheme different than the second modulation and coding scheme.

6. The method of claim **1**, wherein determining the configuration comprises determining a first channel coding scheme for the peak suppression information different than a second channel coding scheme for the received data signal, wherein the first channel coding scheme corresponds to a greater redundancy relative to the second channel coding scheme or a same redundancy relative to the second channel coding scheme.

7. The method of claim **1**, wherein the peak suppression information of a symbol duration is repeated across at least a subset of one or more layers of all layers of a multiple-input multiple-output layer configuration.

8. The method of claim **1**, further comprising:

transmitting an indication of a peak reconstruction capability of the UE; and

receiving the configuration for multiplexing the peak suppression information via the downlink shared channel in response to the transmitted indication of the peak reconstruction capability of the UE.

9. The method of claim **1**, further comprising determining, based at least in part on the configuration, a location in a downlink control channel of the peak suppression information corresponding to a last symbol duration of the downlink shared channel.

10. The method of claim **9**, wherein the location comprises a first symbol duration of a second slot associated with the downlink shared channel, the second slot subsequent to the first slot or the last symbol duration of the downlink shared channel.

11. A method for wireless communication at a network device, comprising:

determining a configuration for multiplexing peak suppression information via a downlink shared channel, the configuration indicating a pattern of resource elements for the peak suppression information via the downlink shared channel;

deconstructing a downlink data message into a data signal and the peak suppression information;

determining that the peak suppression information corresponds to a subset of amplitude peaks of the data signal above a threshold amplitude;

frequency multiplexing the data signal with the peak suppression information based at least in part on the determined configuration; and

transmitting, via the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

12. The method of claim **11**, wherein the pattern of resource elements for the peak suppression information uniformly positions the resource elements across frequency via the downlink shared channel.

13. The method of claim **12**, wherein frequency multiplexing the data signal with the peak suppression information comprises multiplexing, based at least in part on the configuration, the peak suppression information associated with a first symbol duration of the downlink shared channel with the data signal associated with a second symbol duration of the downlink shared channel, the first symbol duration after the second symbol duration.

14. The method of claim **12**, wherein frequency multiplexing the data signal with the peak suppression information comprises multiplexing, based at least in part on the configuration, the data signal associated with a first symbol duration of the downlink shared channel with the peak suppression information associated with a second symbol duration of the downlink shared channel, the first symbol duration after the second symbol duration.

15. The method of claim **12**, wherein deconstructing the downlink data message comprises deconstructing the downlink data message based at least in part on the data signal being transmitted in a same symbol duration of the downlink shared channel as the peak suppression information.

16. The method of claim **11**, wherein determining the configuration comprises determining that the peak suppression information of a first symbol duration is associated with a different transport block than other peak suppression information of other symbol durations.

17. The method of claim **11**, wherein determining the configuration comprises determining that the peak suppression information of a first symbol duration is associated with a same transport block as other peak suppression information of other symbol durations.

18. The method of claim **11**, wherein determining the configuration comprises determining that a same modulation and coding scheme is used for the peak suppression information and the data signal.

19. The method of claim **11**, wherein determining the configuration comprises determining that a first modulation and coding scheme is used for the peak suppression information and a second modulation and coding scheme is used for the data signal, the first modulation and coding scheme different than the second modulation and coding scheme.

20. The method of claim **11**, wherein determining the configuration comprises determining a first channel coding scheme for the peak suppression information different than a second channel coding scheme for the data signal, wherein the first channel coding corresponds to a greater redundancy relative to the second channel coding scheme or a same redundancy relative to the second channel coding scheme.

21. The method of claim **11**, wherein the peak suppression information of a symbol duration is repeated across at least a subset of all layers of a multiple-input multiple-output layer configuration.

22. The method of claim **11**, further comprising:

receiving an indication of a peak reconstruction capability of a user equipment (UE); and

transmitting the configuration for multiplexing the peak suppression information via the downlink shared channel in response to the received indication of the peak reconstruction capability of the UE.

23. The method of claim **11**, further comprising determining, based at least in part on the configuration, a location in a downlink control channel of the peak suppression information corresponding to a last symbol duration of the downlink shared channel.

24. The method of claim **23**, wherein the location comprises a first symbol duration of a second slot associated with the downlink shared channel, the second slot subsequent to the first slot or the last symbol duration of the downlink shared channel.

25. The method of claim **11**, further comprising determining, based at least in part on the configuration, a modulation and coding scheme for a last symbol duration of the downlink shared channel, wherein all resource elements of the last symbol duration of the downlink shared channel comprise data information based at least in part on the determined modulation and coding scheme for the last symbol duration.

26. The method of claim **11**, wherein the peak suppression information comprises one or more of amplitude information associated with one or more peaks of the transmitted data signal, position information associated with one or more peaks of the transmitted data signal, and phase information associated with one or more peaks of the data signal.

27. An apparatus for wireless communication at a user equipment (UE), comprising:

a processor,

memory coupled with the processor; and

instructions stored in the memory and executable by the processor to cause the apparatus to:

determine a configuration for frequency multiplexing peak suppression information via a downlink shared channel, the configuration indicating a pattern of resource elements for the peak suppression information via the downlink shared channel;

receive, via the downlink shared channel based at least in part on the determined configuration, the peak suppression information frequency multiplexed with a data signal in a first slot;

determine that the peak suppression information corresponds to a subset of amplitude peaks of the received data signal above a threshold amplitude;

reconstruct a downlink data message based at least in part on the received data signal and the received peak suppression information; and

decode the reconstructed downlink data message.

28. An apparatus for wireless communication at a network device, comprising:

a processor,

memory coupled with the processor; and

instructions stored in the memory and executable by the processor to cause the apparatus to:

determine a configuration for multiplexing peak suppression information via a downlink shared channel, the configuration indicating a pattern of resource elements for the peak suppression information via the downlink shared channel;

deconstruct a downlink data message into a data signal and the peak suppression information;

determine that the peak suppression information corresponds to a subset of amplitude peaks of the data signal above a threshold amplitude;

frequency multiplexing the data signal with the peak suppression information based at least in part on the determined configuration; and

transmit, via the downlink shared channel according to the determined configuration, the peak suppression information frequency multiplexed with the data signal in a first slot.

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